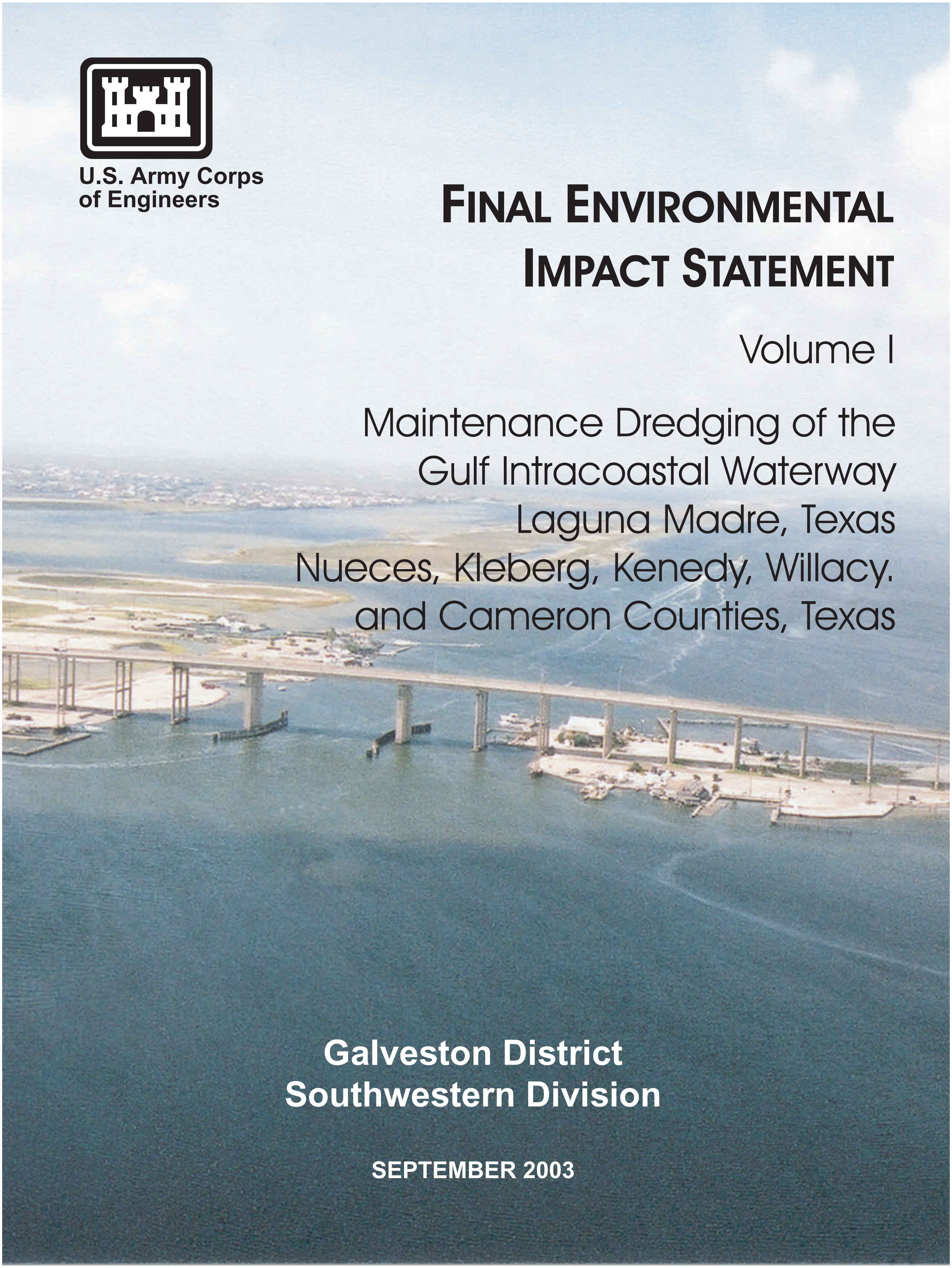

U.S. Army Corps of Engineers

Final Environmental Impact Statement

Volume I

Maintenance Dredging of the Gulf Intracoastal Waterway Laguna Madre, Texas Nueces, Kleberg, Kenedy, Willacy. and Cameron Counties, Texas

Galveston District
Southwestern Division

SEPTEMBER 2003

Abstract

Final
Environmental Impact Statement

Maintenance Dredging of the Gulf Intracoastal Waterway Laguna Madre, Texas
Nueces, Kleberg, Kenedy, Willacy, and Cameron Counties, Texas

The responsible agency is the U.S. Army Engineer District, Galveston.

Abstract: In response to concerns about the adequacy of the 1975 Environmental Impact Statement (EIS) for Maintenance Dredging Gulf Intracoastal Waterway Texas Section – Main Channel and Tributary Channels and a lawsuit challenging that EIS, the U.S. Army Corps of Engineers decided to pursue an EIS and Dredged Material Management Plan (DMMP). The State of Texas, represented by the Texas Department of Transportation (TxDOT) is the local sponsor.

To assist with the development of the scope of environmental studies and the DMMP, the USACE formed an Interagency Coordination Team (ICT). The ICT comprised representatives from TxDOT, Texas General Land Office, Texas Commission on Environmental Quality, Texas Parks and Wildlife Department, Texas Water Development Board, National Marine Fisheries Service, U.S. Environmental Protection Agency, U.S. Fish and Wildlife, and USACE. Environmental studies pertaining to the Laguna Madre which included water and sediment quality and tissue chemistry, benthic macroinfauna analysis, open-water placement, models of circulation and sediment transport, seagrass distribution and productivity, economic impacts, contaminant assessment, depth measurement and bottom classification, and effects to piping plovers. The ICT also developed primary list of concerns that were addressed during the study process and are addressed in this EIS including water and sediment quality; coastal community types; finfish and shellfish resources; wildlife resources; threatened and endangered species; hazardous, toxic, and radioactive wastes; cultural resources; and socioeconomic resources.

The Laguna Madre main channel section currently utilizes 61 Placement Areas (PAs) for contract pipeline placement operations. The proposed Federal action is to continue maintenance dredging of the Laguna Madre section of the Gulf Intracoastal Waterway, which extends 117 miles from the John F. Kennedy Causeway to the old Queen Isabella Causeway, with modification in management of the dredged material to reduce impacts to the Laguna's resources. Periodic maintenance dredging of the Laguna Madre section must be accomplished to prevent shoaling of the channel to depths that would inhibit or curtail navigation. Ten alternatives each for six separate reaches of the Laguna were originally examined. Subsequently, after some of these alternatives had been eliminated from further consideration in some or all of the reaches, subsets of these alternatives were examined for each of the 61 PAs. Based on the environmental impacts, engineering feasibility, and economic considerations, the recommended plan consists of the DMMP developed with the assistance of the ICT.

THE OFFICIAL CLOSING DATE FOR THE RECEIPT OF COMMENTS IS 30 DAYS FROM THE DATE ON WHICH THE NOTICE OF AVAILABILITY OF THIS FINAL EIS APPEARS IN THE FEDERAL REGISTER.

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Note: Copies of the EIS can be obtained from Dr. Roberts and the EIS can be viewed on the District webpage: http://www.swg.usace.army.mil/.

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SUMMARY

Major Conclusions and Findings

Major factors affecting formulation of the Maintenance Dredging Gulf Intracoastal Waterway Texas Project, were effects on estuarine resources, especially seagrasses; colonial waterbirds; water quality, mainly turbidity; Essential Fish Habitat, and cumulative impacts. No water or sediment quality impacts are expected from the No-Action or DMMP alternative, aside from the turbidity associated with dredging and placement. These will be reduced with the DMMP since there will be less open bay unconfined placement. Impacts will occur from both alternatives to submerged aquatic vegetation (SAV, 1,307 fewer acres with the DMMP alternative), tidal flats (49.3 acres fewer with the DMMP alternative), and coastal wetlands (potentially more to high salt marsh) with the DMMP alternative. A total of 115 more acres of open-bay unvegetated bottom will be affected with the DMMP alternative, which will increase impacts to finfish and shellfish resources; however, the overall reduction in impacts to SAV will reduce impacts to finfish and shellfish resources. Impacts to wildlife resources will be minimal with either alternative but the DMMP alternative will improve colonial waterbird habitat by expanding or modifying some islands and reduced impacts to SAV will benefit redhead ducks. There will be few or no impacts to threatened and endangered species occurring in the project area. Impacts to hazardous, toxic, and radioactive waste; air quality; noise; cultural resources; and socioeconomic resources are expected to be minimal.

There were few opportunities for beneficial uses of dredged material placement. However, where those opportunities occurred, e.g., creation of colonial waterbird habitat and enhancement of islands associated with PAs within the Padre Island National Seashore (PINS), they are included in the DMMP. The current dredged material placement practice for the Laguna Madre section of the GIWW consists primarily of unconfined open-bay placement with upland placement where it crosses the Land Bridge and a few other areas, notably near the mouth of the Arroyo Colorado. The main channel through the Laguna Madre has 63 PAs available, of which 61 are intermittently utilized, directly impacting over 9,000 acres of bay bottom. The DMMP will reduce the amount of unconfined open-bay placement and the concomitant impacts.

Recommended Plan

The recommended plan is the continued maintenance of the Gulf Intracoastal Waterway (GIWW) in the Laguna Madre from the JFK Causeway to the old Queen Isabella Causeway using the DMMP developed in cooperation with the ICT. The DMMP outlines the management plans for placing dredged material from maintenance dredging of the Laguna Madre on a PA-by-PA basis. The PAs will be managed primarily for reducing impacts to nearby seagrass habitat, but some sites will be managed for bird use, vegetation control, or public recreation use. The management plans in the DMMP will be reviewed prior to each dredging event to ensure the best management practice for each PA is incorporated to the extent practicable.

Other Major Conclusions and Findings

This EIS has been prepared to satisfy the requirements of all applicable laws and regulations using the Council of Environmental Quality's National Environmental Policy Act regulations (40 CFR Part 1500) and the USACE's regulation ER 200-2-2 (33 CFR 230). Information gathered from a multitude of sources was used to establish a list of the primary concerns that should be addressed during the study process in the Laguna Madre segment of the GIWW. The following is a brief summary of the effects of the No Action alternative and the recommended plan on the environmental resources of the Laguna Madre.

Water Quality

The most obvious impact of the No-Action alternative to the estuarine water column is turbidity associated with maintenance dredging and placement. Concern has been expressed relative to the impact that the present maintenance dredging practice has on total suspended material and, thus, turbidity. Several studies were recommended by the ICT to address this concern.

One of those studies found that where an association between total suspended solids (TSS) and currents appears to exist, it seems to be governed more by current direction than current speed. The modeling studies showed that small impacts were to be expected from turbidity from open-bay unconfined dredging and placement. Since impacts were shown by the modeling and since there have been documented concerns, open-bay unconfined placement was eliminated to the extent possible, and a seasonal restriction was imposed on the remaining open-bay placement to limit the impacts to seagrass. In the DMMP alternative, use of deflectors to reduce the energy of the discharge water; use of training levees to direct the material on unconfined islands; use of deeper, unvegetated water for some open-bay sites; and partially or completely confining other sites would reduce scouring, turbidity, and other associated impacts.

Both the No-Action and DMMP alternatives may or may not affect dissolved oxygen concentrations in the water column at PAs. During studies for this FEIS, it was noted that low oxygen was not found as a concern by studies of the water chemistry of the Laguna Madre.

Based on the results of sediment studies conducted for this FEIS, it has been asserted that dredging and dredged placement operations associated with the No-Action alternative and the DMMP alternative may cause or exacerbate brown tide in the Laguna Madre because resuspension of sediments might release a significant amount of NH_4^+ into the water column. Brown tide has adapted to low light, highly turbid waters and preferentially takes up NH_4^+ as a nitrogen source. It has been conjectured that NH_4^+ inputs during dredging events, along with light reduction could replicate the original brown tide event in a localized manner. However, while the brown tide organism is present in the Laguna Madre, maintenance of the GIWW since the GIWW was dredged in 1949 has not been reported to cause brown tide events. The onset of brown tide occurred after severe freezes in 1989 caused a large die-off of fish and benthos, resulting in high NH_4^+ concentrations and a subsequent collapse in the zooplankton community.

Sediment Quality

The sediment quality of maintenance material was not determined to be a cause for concern. However, questions have been raised concerning concentrations found mainly near Baffin Bay and the Arroyo Colorado. The DMMP alternative removes more maintenance material from the Laguna Madre system, and makes it preferable to the No-Action alternative from a sediment quality viewpoint. No indication of toxicity has been determined by past bioassays or bioaccumulation studies; therefore, neither alternative presents a concern from a toxicity testing perspective.

Since the DMMP alternative includes less unconfined placement than the No-Action alternative, there should be a reduction in the amount of resuspended maintenance material and a concomitant decrease in shoaling in the affected reaches and the frequency of dredging. However, only future dredging will determine whether all sources and sinks in such a vast system were, or can be, accurately defined and, thus, the significance that the additional confinement of maintenance material will have on dredging frequency.

Special Aquatic Habitat

Potential seagrass loss on a localized scale around a PA is expected from dredged maintenance material placement as a result of both direct and indirect effects. Only total confinement of dredged material of ocean placement would totally prevent direct impacts to the seagrass beds, though the conveyance to the upland sites or the Gulf would impact seagrass habitat, along with other estuarine and upland habitat. Overall 1,307 fewer acres of seagrass will be impacted with the DMMP alternative.

For both the No-Action alternative and the DMMP alternative some wetlands, both low and high salt marsh, will be impacted in the locations where placement will occur, but since the DMMP alternative relies more heavily on placement on existing emergent islands in the PAs than does the No-Action alternative, more impacts to high salt marsh can be expected with the DMMP alternative.

The No-Action alternative will continue temporary impacts to tidal flat habitat with current disposal practices in areas associated with the existing placement islands. In total, 137.2 acres of tidal flats are expected to be impacted, both inside and outside of the PAs, with the No-Action alternative. The maximum area calculated to be impacted by the DMMP alternative is 87.9 acres, 49.3 acres fewer than with the No-Action alternative.

No live oyster reefs occur within the Laguna Madre ecosystem, with the exception of the South Bay population and, perhaps, a few unrecorded, isolated patchy reefs in the Lower Laguna Madre. The nearest PA is located roughly 2.5 miles north and on the other side of the Brownsville Ship Channel from the live oysters in South Bay, and, therefore, adverse impacts are not expected to occur as a result of dredging and dredged material placement operations for either the No-Action or DMMP alternative. Remnant serpulid reefs and coquina rock outcrops are found in the project vicinity, but impacts have not been reported in the past and the DMMP alternative is not expected to impact them.

The No-Action alternative and the DMMP include placement on islands or upland areas in existing PAs where shorelines occur. Shorelines associated with these islands may be buried with maintenance material; however, erosion will allow the areas to be restored or the shoreline will move its relative position and become reestablished, a short-term temporary effect. No negative impacts to sand dunes will occur, however there could be disturbance to beach areas on existing PAs. Compared with the large area of coastal shore area and beaches in the project area, the impacts associated with either alternative are considered significant.

The No-Action and the DMMP alternative will place material on islands in PAs that support grassland communities. Impacts to these areas may be permanent; long-term temporary; or short-term temporary depending on the depth of the maintenance material placed on the island and frequency of dredging cycles. The upland PAs will revegetate without frequent maintenance material placement. The DMMP alternative will also not impact any mainland or barrier island grassland communities.

Finfish and Shellfish Resources

Although water column turbidity would increase in open-bay habitats during dredging activities, such effects are usually temporary and local. At PAs where new levees are proposed, there would be one-time water column turbidity increases during construction. Finfish and shellfish communities are altered over time; however, there are indications that mobile organisms are able to respond quickly to dredged material placement. Notwithstanding the potential harm to some individual organisms, compared with the existing condition, no significant impacts on finfish or shellfish populations are anticipated from the maintenance dredging and placement operations for the No-Action alternative or the DMMP alternative.

Repeated dredging and placement operations may temporarily reduce the quality of recreational and commercial fisheries in the vicinity of dredging operations. There is the possibility under the DMMP alternative that Emmord's Hole, a prime recreational fishing spot in the ULM, would be used as a dredged material disposal site. However, this site would only be used as a last choice alternative on the recommendation of the ICT. Commercial fishing for shellfish in the Laguna Madre is very limited, therefore no impacts are expected for the No-Action alternative or the DMMP alternative. Since there would be fewer dredged material plumes with the DMMP alternative, any impacts from turbidity on filter-feeding organisms would be reduced with this alternative in comparison to the No-Action alternative.

Overall, 115 more acres of open-bay bottom will be removed from the ecosystem by the DMMP alternative by fully confining more PAs. Given the large amount of open-water habitat in the Laguna Madre, this is not considered a significant impact, especially considering the reduction in turbidity and in impacts to seagrasses and algal/sand flats as an overall result of implementation of the DMMP alternative.

Approximately 4,887 acres of open water, based on open-bay (unvegetated) bottom impacts, would be affected by the DMMP alternative, which is 115 more than the No-Action alternative. However, the DMMP alternative proposes to reduce impacts to submerged aquatic vegetation (SAV) by 1,307 acres, relative to the No-Action alternative. Thus, impacts to adult and juvenile brown, white, and pink shrimp; red drum; and adult gray snapper would be minimized by reducing impacts to SAV beds. Harmful effects would occur if sediment covers fish spawning grounds and bottom areas critical to juveniles. However, with the DMMP alternative, runoff of dredged material onto SAV would be reduced through the use of training levees and total confinement of some PAs.

Wildlife Resources

Impacts to terrestrial wildlife species or habitats within or near the project area as a result of the No-Action or DMMP alternatives may include short-term effects resulting from the noise and physical disturbance during dredging activities, as well as long-term effects resulting from habitat modification.

Long-term effects to terrestrial wildlife species and habitats would occur primarily as a result of habitat modification. Of 35 bird rookeries occurring on tidal flats and emergent dredged material PAs adjacent to the GIWW, 23 are located in existing or proposed PAs. The majority of PAs currently have bird management plans for dredging, conveyance, and placement operations, which generally allow for the avoidance of placement in major rookeries and include restrictions on placement of material during the breeding season in those areas periodically used.

The DMMP alternative was designed to improve colonial waterbird habitat, and thus, is an improvement over the No-Action alternative. While this cannot be precisely quantified, the DMMP followed the recommendations of the latest versions of the Shorebird Management Plan and the Padre Island National Seashore Management Plan, available to the ICT to the extent practicable.

Threatened and Endangered Species

Based on available records, no Federally or State-listed plant species occur within 2 miles of the proposed project activities. No suitable habitat for the species discussed in Section 3.7.1 exists on any of the existing or proposed PAs. Therefore, no impacts to protected plant species are anticipated from either the No-Action or DMMP alternatives.

The No-Action and DMMP alternatives would result in little or no immediate direct impacts to any species or designated Critical Habitat protected by the Endangered Species Act within the project area. Changes to habitats, over time, would be expected as a result of various natural influences. In general, dredged material placement activities associated with the No-Action and DMMP alternatives may affect habitats used by the piping plover and State-threatened colonial waterbirds, and maintenance dredging may impose minor, temporary impacts on sea turtles. Increased boat traffic within the project area during maintenance dredging and placement may also temporarily disturb various aquatic species and may increase erosion/sedimentation in some areas. However, these impacts are considered short-term and generally insignificant.

Two State-listed amphibian species, the south Texas siren and the black-spotted newt, are known to occur within the project area. These freshwater species would not be affected by the project.

Several species of birds that receive protection at the Federal or State level are listed as potentially occurring within the project area counties. The primary direct impact would be from disturbance during dredging and placement activities that may cause roosting birds to be temporarily displaced. Such activities are short-term and periodic, and abundant suitable habitats occurring within the Laguna Madre system would allow for short-term displacement. Specific potential impacts to those protected avian species most likely to be impacted by the project are described below.

Piping Plover

Although approximately 6,588 acres under the No-Action alternative and 6,210 acres under the DMMP alternative of piping plover Critical Habitat would be affected by project activities (primarily placement of dredged material), the No-Action and DMMP alternatives should not directly affect the piping plover. Because of the limited amount of suitable habitat on active PAs and the great amount of suitable habitat adjacent to these PAs, impacts would be minimal. No Critical Habitat in Reach 1 will be impacted by placement of dredged material. Under the DMMP, levees would be built on some PAs, such as PA 176, which will contain or train the material away from suitable habitat areas. FWS will be contacted prior to levee construction at PA 176 to ensure no impacts to the piping plover would occur.

Within Reach 2, six PAs fall within Critical Habitat unit TX-3 (subunit 3), but do not appear to contain the primary constituent elements needed for piping plover use. The PAs will be examined more closely before placement occurs in this Reach. All PAs within Reach 3 coincide with Critical Habitat unit TX-3 (subunit 3). No management changes are proposed for PAs within this reach under the DMMP alternative. No impacts are anticipated from either alternative in Reach 3, since the PAs do not appear to contain the primary constituent elements needed for piping plover use.

Piping plovers were rarely, if ever, observed to use the PAs within reaches 4, 5, and 6; therefore, impacts to the piping plover from direct project activities within this reach are expected to be negligible. With the exception of PA 226, none of the designated PAs fall within designated Critical Habitat.

State-Threatened Colonial Waterbirds

Three State-threatened colonial waterbirds, the white-faced ibis, reddish egret, and sooty tern, are known to nest on dredged material PAs within the project area. Neither the No-Action nor the DMMP alternative should directly impact these State-listed waterbirds outside of the nesting season because they are mobile enough to avoid direct impacts from dredged material placement. Under the DMMP alternative, impacts to these species would be lessened by various aspects of the plan, including avoiding islands or portions of islands on some PAs where birds are nesting; building up or reinforcing emergent habitats on several PAs for bird use; or avoiding placement activities during the primary nesting season.

No Federally listed and only three State-listed species of fish (opossum pipefish, river goby, and blackfin goby) are known to occur within the project area counties, none of which should be impacted by either alternative.

The No-Action and DMMP alternatives should have no impacts on the West Indian manatee, or on any Federally or State-listed terrestrial mammals potentially occurring within the project area counties.

The loggerhead, Kemp's ridley, and green sea turtles are the most likely of the five Federally and State-listed sea turtles to occur within the project area. If sea turtles occur in the project area, dredging activities may negatively impact them. Dredged material placement would increase turbidity in the project area, but sea turtles are mobile enough to avoid disturbed sites. Project impacts would be temporary and local in nature. Cutterhead suction dredges would be used which move very slowly and can be avoided by all species of sea turtles. Since all dredging of the project area would be performed by cutterhead dredges rather than hopper dredges, no significant adverse impacts to sea turtles from maintenance dredging operations are anticipated.

The No-Action and DMMP alternatives should not affect the American alligator, since they would likely avoid locations where dredging and placement activities were actively occurring.

The No-Action and DMMP alternatives should have no impacts on the Texas hornshell, an extremely rare candidate species known only from the Rio Grande system.

Hazardous, Toxic and Radioactive Waste

The impacts from hazardous material use and handling during dredging activities associated with the project pose a minimal risk of impacts to the environment.

Air Quality

Because the amount of dredging for the preferred alternative is expected to be the same as or slightly less than for current activities, air contaminant emissions from the DMMP alternative would result in approximately the same or slightly less annual average emission rates and localized, minor short-term impacts on air quality as the No Action alternative.

Noise

Noise from dredging activities would essentially be the same under either the No-Action alternative or the DMMP alternative.

Cultural Resources

It is anticipated that maintenance dredging along the Laguna Madre section of the GIWW under either the No-Action or DMMP alternative will have no adverse impacts on terrestrial cultural resource sites. There are also no recorded shipwrecks in the vicinity of the new PAs; even though there is a potential for unrecorded wrecks to be present in some of these areas.

Socioeconomics

The effects on employment and economics or the effects on population and community cohesion from the DMMP alternative would be equivalent to those described for the No-Action alternative.

Dredging and placement activities under the No-Action and DMMP alternatives would have little effect on recreation and tourism within the project area. However, loss of Coastal (fishing) Cabins in some of the PAs will be an effect from the DMMP alternative.

No impacts to land use are anticipated from the No-Action or DMMP alternative nor would either be expected to create disproportional impact on any segment of the surrounding communities.

Cumulative Impacts

Cumulative impacts due to past, existing, and reasonably foreseeable future projects, along with the DMMP alternative, were found to produce a net positive cumulative impact in the project area. Although some parameters would experience negative impacts, most of these impacts would be temporary and minor. Benefits realized through creation and protection of seagrass and tidal flats habitat by the DMMP alternative and some other projects, not including mitigation from other reviewed projects, resulted in a net improvement to the Laguna Madre, relative to the No-Action alternative.

Areas of Controversy and Unresolved Issues

An area of controversy concerns the use of Emmord's Hole as a placement site for some dredged maintenance material that in excess of the PINS Management Plan. Many local fishermen oppose the use of deep, unvegetated areas in Emmord's Hole because they believe it will impact the quality of the popular fishing site. However, this site will only be used as a last resort and only upon the recommendation of the ICT after carefully weighing the positive and negative impacts of this action.

An unresolved issue concerns the use of PAs that are located inside the boundary of PINS. The National Park Service (NPS), Department of the Interior, has stated that the USACE is required to secure a special use permit from the NPS before using PAs that are within the boundaries of the PINS. The USACE's position is that this is not the case, since the USACE holds easements, which predate the creation of PINS by Congress and the Arroyo Colorado River Authority of Cameron and Willacy Counties never transferred the rights to the surface land to PINS. However, the DMMP follows the PINS Management Plan for these PAs to the extent practicable and the USACE will coordinate use of its easements with PINS, if such coordination takes place in a timely manner, and will adopt all reasonable practices to protect PINS' resources in accordance with the ICT recommendations and this Final EIS.

Relationship to Environmental Requirements

The recommended plan is in full compliance with the environmental requirements applicable to this project. A discussion of the applicable laws can be found in Section 6.0 of the FEIS.

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1.0 NEED FOR AND OBJECTIVES OF ACTION

1.1 PURPOSE OF THE ENVIRONMENTAL IMPACT STATEMENT

The Environmental Impact Statement (EIS) for Maintenance Dredging Gulf Intracoastal Waterway Texas Section – Main Channel and Tributary Channels was published in October 1975. The EIS identified and evaluated the environmental impacts of continued maintenance dredging of the Texas Section of the Gulf Intracoastal Waterway (GIWW) and tributary channels. In the original EIS, alternatives were addressed that would reduce environmental effects while enhancing economic and social conditions.

The specific action proposed in the 1975 EIS was to maintain the Texas Section of the Gulf Intracoastal Waterway (GIWW) and its tributary channels by periodic dredging of shoal deposits (U.S. Army Corps of Engineers [USACE], 1975). The main channel was maintained at a 12-foot depth and a 125-foot bottom width with tributary channels generally smaller in size than the main channel. Cutterhead suction dredges, using hydraulic pipelines to dispose of dredged material, were the typical means of dredging proposed, with the exception of the Port Mansfield Channel that was to be maintained by hopper dredge (USACE, 1975). At the time of the EIS, the environmental impact and environmental effects of the proposed actions were addressed.

In November 1989, the USACE completed a Reconnaissance Report including an initial appraisal of the entire Texas section of the GIWW. At this time, the question of the inadequacy of the EIS was first raised when an interagency task force (Gulf Intracoastal Waterway Maintenance Dredging Working Group) challenged sections of the existing EIS relative to its compliance with various environmental statutes. The members of the task force included the U.S. Fish and Wildlife Service (FWS), National Marine Fisheries Service (NMFS), National Park Service (NPS), Texas General Land Office (GLO), and Texas Parks and Wildlife Department (TPWD). Their issue paper, entitled "Evaluation of the U.S. Army Corps of Engineers' 1975 Environmental Impact Statement on Maintenance Dredging of the Gulf Intracoastal Waterway – Texas Section," recommended that a supplemental EIS be prepared (USACE, 1994). Several environmental groups and one land owner, including the Lower Laguna Madre Foundation, the National Audubon Society, and the King Ranch also questioned the environmental effects of open-bay placement practices and the adequacy of the EIS in addressing those effects.

Therefore, the first phase of additional Section 216 studies was initiated in 1993. The focus of this reconnaissance study was to address problems and concerns along the lower reach of the existing, Federally maintained, Texas section of the GIWW. In particular, the purposes of this study were 1) to evaluate commercial shallow-draft navigation operational problems and needs, 2) to address environmental and cultural resources concerns, and 3) to evaluate the potential rerouting of the Channel near Port Isabel (USACE, 1994). The USACE Galveston District was responsible for the general management of that study, with the State of Texas, represented by the Texas Department of Transportation (TxDOT), acting as the local sponsor. In addition, various other Federal and State agencies provided considerable input during this study. A Planning Aid Report was prepared by the FWS and three public scoping workshops were conducted in 1993 (USACE, 1994).

Continuing environmental concerns led to a 1994 lawsuit in the U.S. District Court in Brownsville, Texas, involving the National Audubon Society et al. vs. U.S. Army Corps of Engineers, Civil Action No. B-94-254. Final judgment on this case occurred while the USACE was conducting the Section 216 study described above. The plaintiffs' claims were denied and the case dismissed on October 13, 1994. The plaintiffs appealed the case to the Fifth Circuit Court of Appeals and submitted their brief on October 31, 1995. The USACE agreed to publish a Notice of Intent to Prepare an SEIS, which was published in the Federal Register on February 14, 1996. On April 22, 1996, a stipulation of settlement was filed. The USACE agreed to use its best efforts to complete an SEIS by December 31, 1998; that the USACE would conduct public scoping and evaluate reasonable alternatives in accordance with the National Environmental Policy Act (NEPA); and that the USACE would hold a public scoping meeting in Cameron County before October 1, 1996. Subsequently, a public scoping meeting was held on September 26, 1996.

The recommendations of the task force, coupled with environmental concerns from environmental organizations, and the preliminary findings of the Reconnaissance Study led to finalizing the decision to proceed with a new Final EIS (FEIS). These processes also resulted in the formation of an Interagency Coordination Team (ICT) to help the USACE develop the scope of environmental studies. Additionally, public meetings and workshops were held to obtain information on issues important to Laguna Madre communities (Section 7).

Therefore, the purpose of this FEIS is to update existing information and provide new information and environmental analysis concerning the placement of dredged material from continued maintenance dredging of the GIWW through the Laguna Madre.

1.2 STUDY AUTHORITY AND LOCATION

A draft Reconnaissance Report for addressing problems and concerns along the reach of the GIWW between Corpus Christi and Port Isabel, prepared under Section 216 Authority, was submitted to the USACE for review in 1994. However, the report contained unresolved issues and was completely revised in 1997 after the issues were resolved. The earlier report focused on navigation problems, environmental and cultural resource concerns, restoration measures and long-term disposal options, and the potential rerouting of the Channel near Port Isabel to reduce traffic delays and navigation hazards. The final report determined that this reach of the GIWW is fully functional and does not include any area which poses serious operational problems for commercial navigation and that there is no Federal interest in a channel realignment plan at Port Isabel. Based on these conclusions, the USACE decided that it would be inappropriate to perform an optimization study of channel dimensions as a part of a feasibility study because 1) it is very unlikely that optimization would result in dimensions greater than those that currently exist due to traffic load and dimensions of connecting channels, and 2) Congressional authorization is not required to maintain a channel at dimensions less than those authorized.

Because the need for an EIS and Dredged Material Management Plan (DMMP) still existed as a result of court action, the USACE determined that studies to reevaluate the economic feasibility of the project and prepare a DMMP and EIS would continue under the direction of the Dredged Material Management Program and Operations and Maintenance authority.

1.2.1 Project Location

In the 1975 EIS, the Texas Section of the GIWW (from the Sabine-Neches waterway near Louisiana to Port Isabel near Mexico) was broken down into three reaches. Reach 3 included the area between the John F. Kennedy Causeway (JFK Causeway) and the Texas-Mexico border. Within the Reach 3 evaluation, two subsections were evaluated including the Encinal Peninsula to the Lower Laguna Madre (LLM) and the LLM to Port Isabel, Texas. In addition, tributary channels, including the Port Mansfield Channel and the Channel to Harlingen, were addressed.

The Laguna Madre is a long, narrow, hypersaline lagoon extending from Corpus Christi Bay to the southern end of South Bay near the Rio Grande. Since most of the public and agency concerns about the project are with maintenance dredging and placement practices in the Laguna Madre, the project area for this FEIS extends from the JFK Causeway, which joins Flour Bluff to Padre Island, to the old Queen Isabella Causeway, which once joined Port Isabel to South Padre Island, and roughly 1 mile inland on the east and west. Figure 1-1 depicts the northern, middle, and southern reaches of the Laguna Madre project area. The coastline of this area extends across five Texas counties: Nueces, Kleberg, Kenedy, Willacy, and Cameron.

The Laguna Madre is subdivided into two basins referred to as the Upper Laguna Madre (ULM) and the LLM, with the two being separated by the Saltillo Flats (Land Bridge). The Land Bridge consists of an extensive area of sporadically inundated tidal flats, which start approximately 10 miles south of the mouth of Baffin Bay and extend southward approximately 35 miles (Coastal Impact Monitoring Program, 1995). The USACE completed construction of the GIWW in the project area in 1949. Upon completion of the GIWW, the ULM and LLM, once separated by the Land Bridge, became permanently connected. The portion of the GIWW that connects the ULM and LLM is commonly referred to as the "Land Cut."

1.3 EXISTING PROJECT

The Laguna Madre section of the GIWW is a link in the chain of navigable channels which extend from Florida to near the Mexican border. On July 23, 1942, Congress authorized enlargement of the Gulf Section of the Intracoastal Waterway to include the Laguna Madre section (USACE, 1975). A shallow-draft navigation channel 12 feet deep and 125 feet wide was authorized for the entire length of the waterway through this portion. Construction on this project was initiated in 1945 and was completed on June 18, 1949 (USACE, 1994).

For purposes of this project, the Laguna Madre section of the GIWW is 117 miles from the JFK Causeway to the old Queen Isabella Causeway. The channel dimensions today remain at 125 feet wide by 12 feet deep, plus allowable overdraft and advanced maintenance for a total of 16 feet. The main channel requires maintenance dredging every 23 to 60 months in selected reaches to remove approximately 200,000 cubic yards (cy) to 3 million cy (MCY) of sediment (USACE, 1994). Maintenance is

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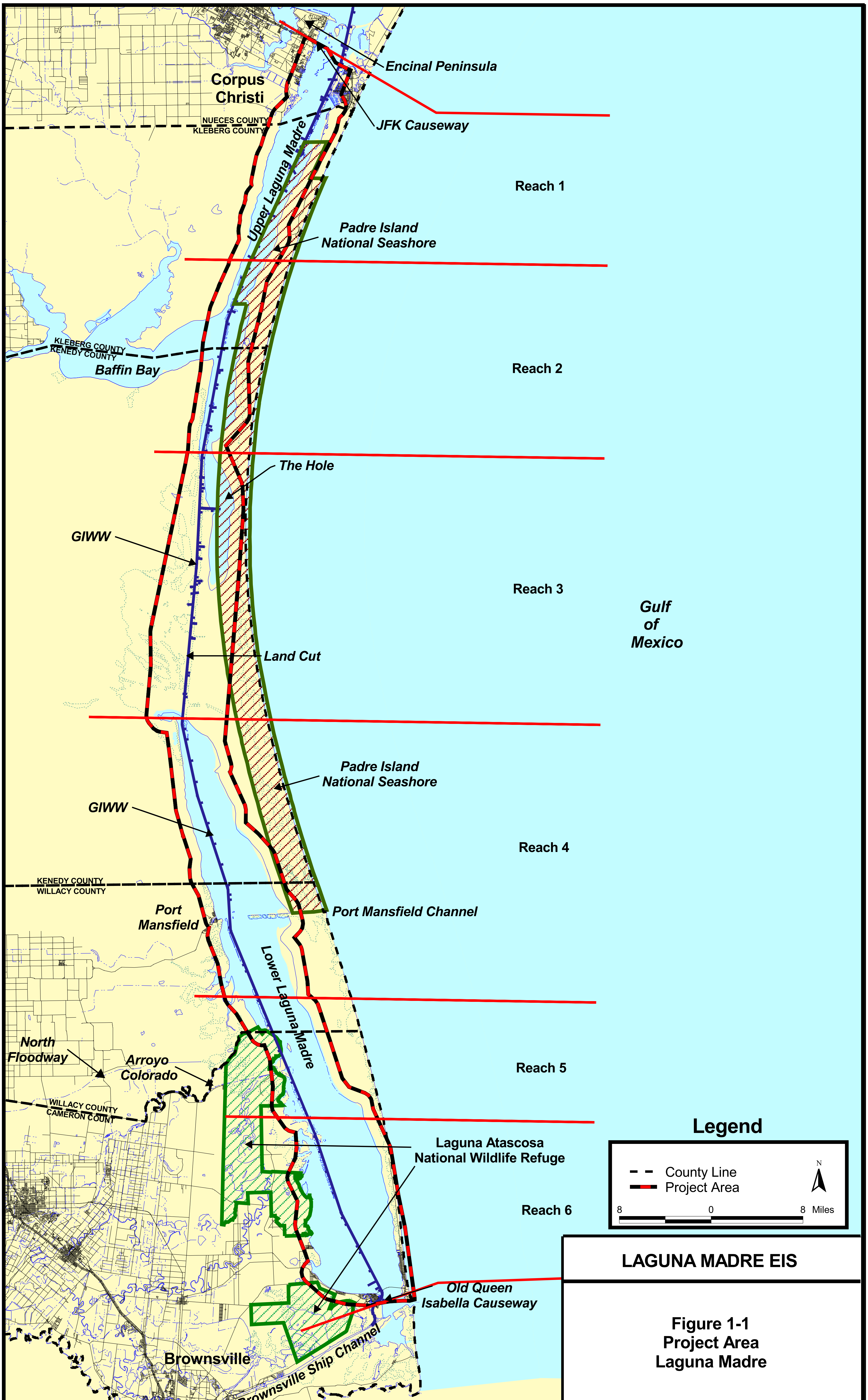

LAGUNA MADRE EIS

Figure 1-1
Project Area
Laguna Madre

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performed by contracted cutterhead suction dredges, and materials dredged are placed by hydraulic pipeline on both upland and open-bay placement areas. The ULM reach includes three water exchange passes, generally 5 feet deep by 200 feet wide, which were constructed to improve water circulation and fish migration in an area known locally as The Hole (approximately channel mile 590) (USACE, 1975). These consist of one of the Humble Oil Channels, between PAs 203 and 204 and centered at 233+200; a channel between PAs 204 and 206, centered at 242+500; and a channel between PAs 206 and 207, centered at 260+150. The LLM reach intersects the GIWW tributary to Port Mansfield (Port Mansfield Channel) and then the Tributary Channel to Harlingen via Arroyo Colorado.

The Laguna Madre main channel section as defined for this FEIS currently utilizes 61 existing placement areas (PAs) for contract pipeline placement operations (Table 1-1). The PAs in this reach are numbered 175 through 240 (excluding PAs 237 and 238, which are used only for Port Isabel small boat harbor channel and PA 205, which is used only for the circulation channel between the GIWW and The Hole) as described below and are depicted on Figure 1-2a through f. There is no record that PAs 175 or 236 have ever been used for placement of maintenance material.

TABLE 1-1

PLACEMENT AREA TYPE AND GENERAL LOCATION

Placement Area	Type	General Location
PAs 175, 177–202	Open-water areas	ULM
PA 176	Partially confined, will be fully confined by next use	ULM
PA 203	Unconfined area	Sand and mud flats
PA 204	Fully confined over all of PA	Sand and mud flats
PA 206	Fully confined over part of PA	Sand and mud flats
PA 207	Fully confined over part of PA	Sand and mud flats
PA 208	Fully confined over part of PA	Sand and mud flats
PAs 209 and 210	Unconfined areas	Sand and mud flats
PA 211	Partially confined	LLM
PAs 212–221, 223, 227–236, and 239	Open-water areas	LLM
PA 222	Partially confined	LLM
PAs 224 and 225	Partially leveed	Channel to Harlingen
PA 226	Fully leveed over all of PA	Channel to Harlingen
PA 240	Partially confined area	Port Isabel

Periodic maintenance dredging of the Laguna Madre section must be accomplished to prevent shoaling of the channel to depths that would inhibit or curtail navigation, since the GIWW provides

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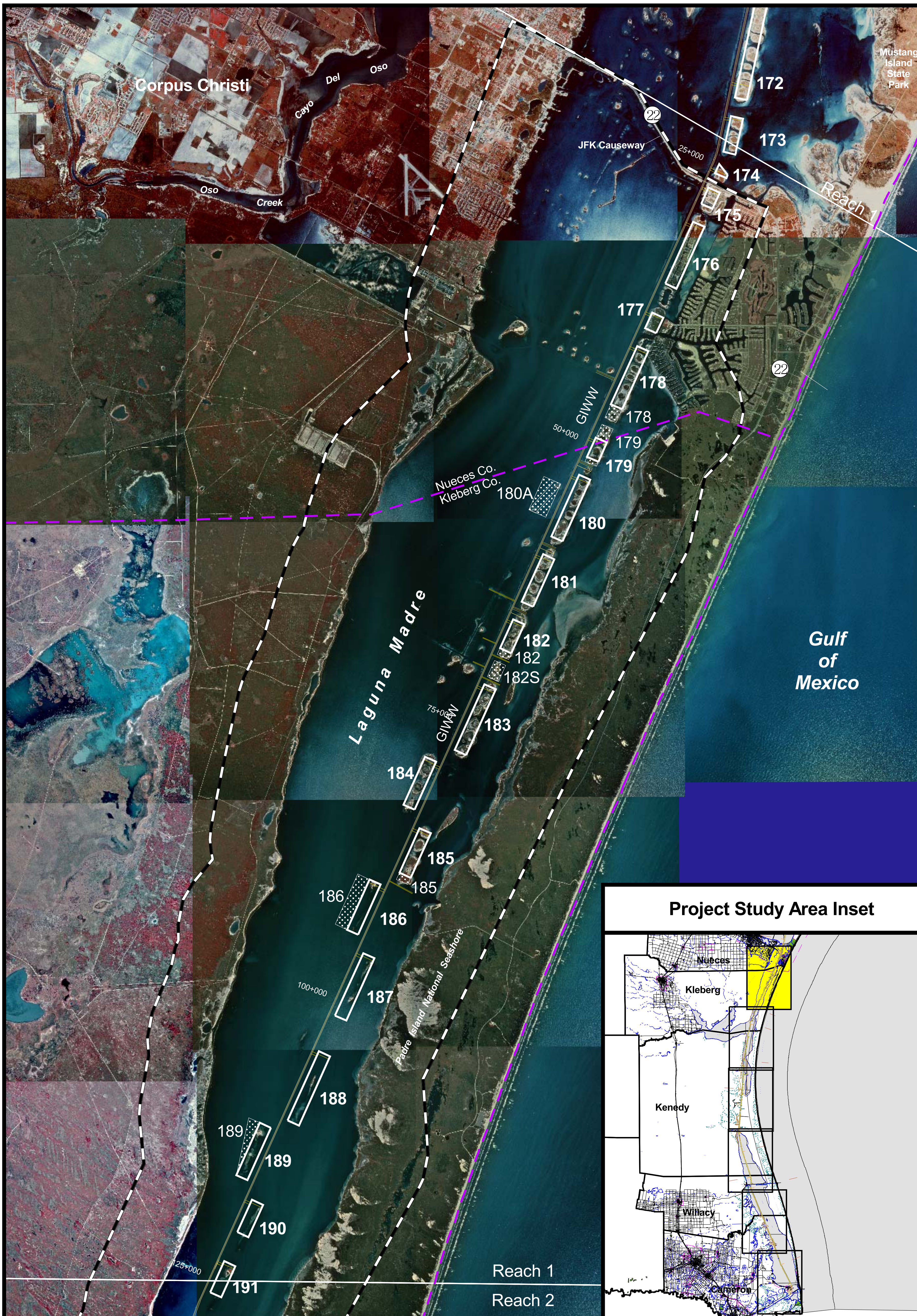

N
W E
S

County Line
Project Area

1 0 1 Mile

8000 0 8000 Feet

233 Existing Placement Area

180A New or Extended Placement Area Under Proposed DMMP

221 Placement Areas Excluded From Proposed DMMP

LAGUNA MADRE EIS

Figure 1-2a
Placement Areas
Laguna Madre

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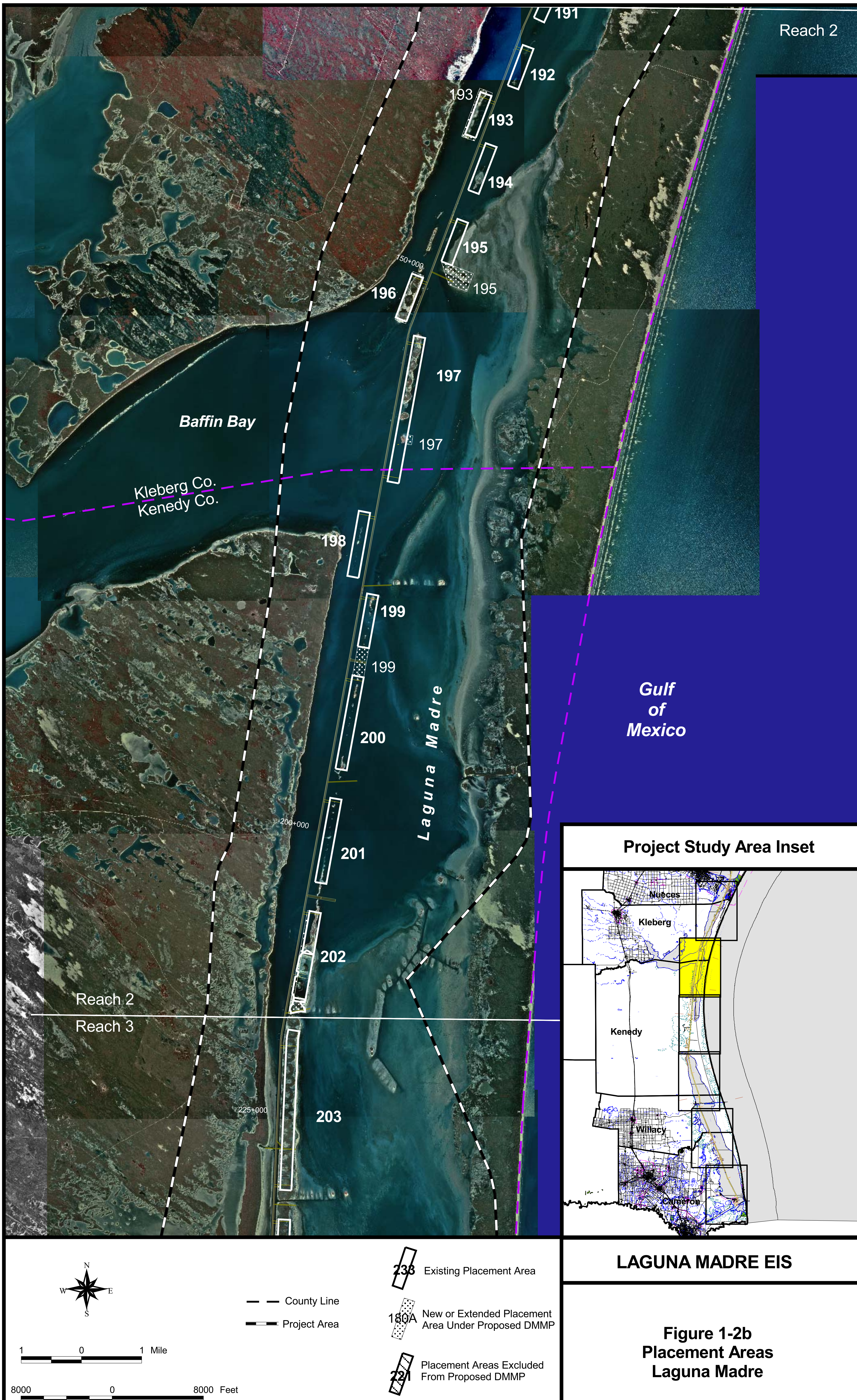

LAGUNA MADRE EIS

Figure 1-2b
Placement Areas
Laguna Madre

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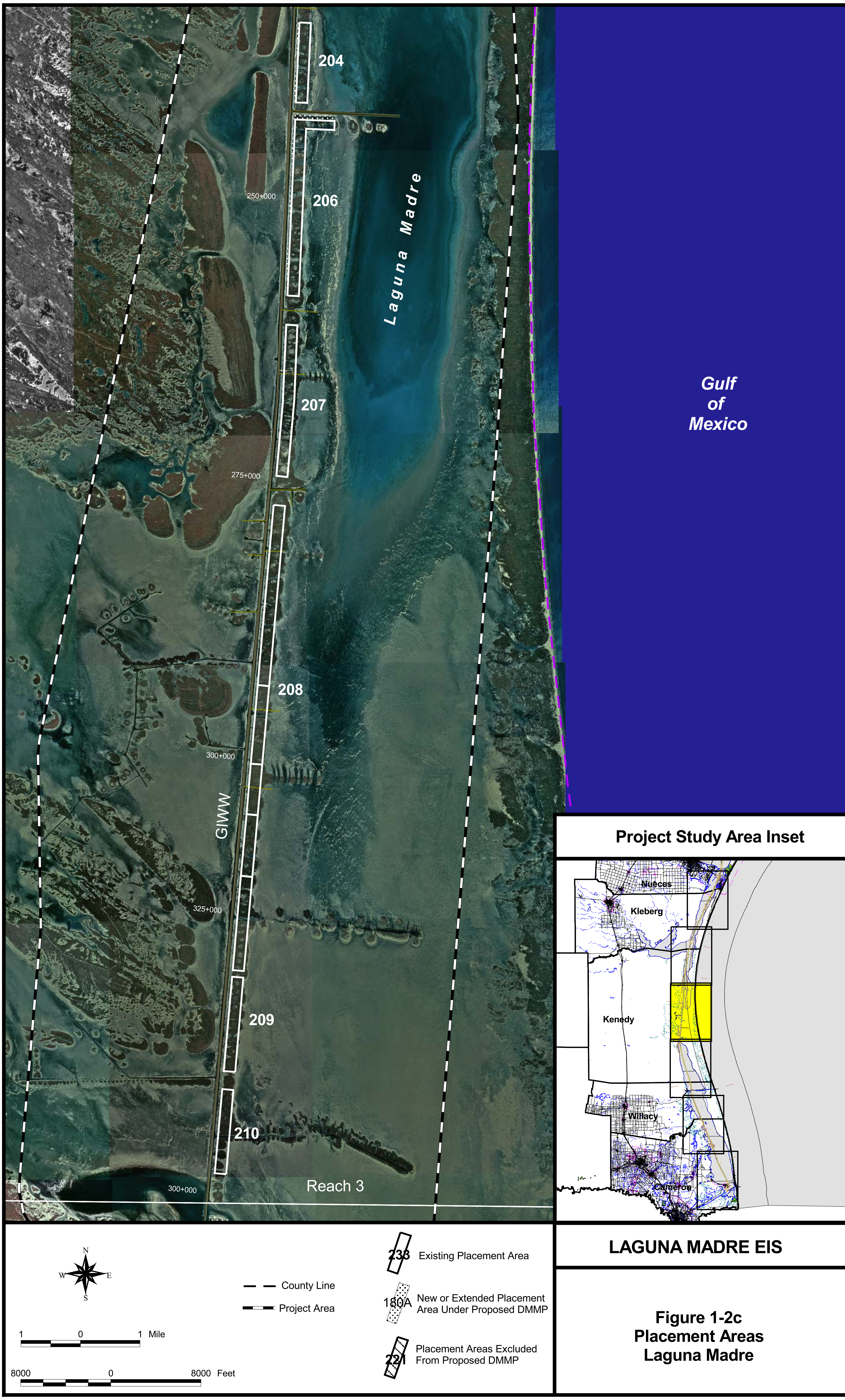

County Line

Project Area

233 Existing Placement Area

180A New or Extended Placement Area Under Proposed DMMP

221 Placement Areas Excluded From Proposed DMMP

LAGUNA MADRE EIS

Figure 1-2c
Placement Areas
Laguna Madre

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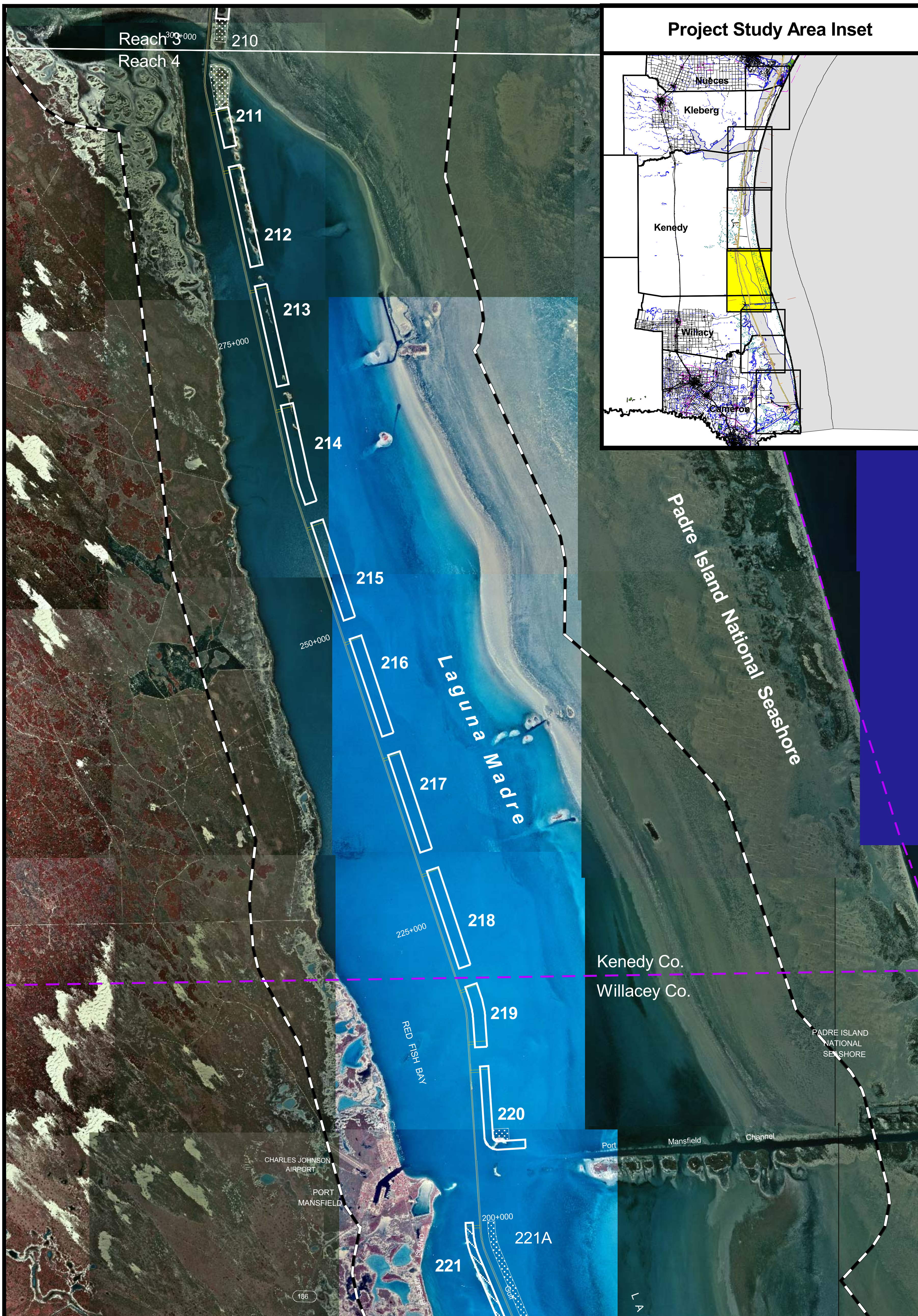

County Line
Project Area

1 0 1 Mile

8000 0 8000 Feet

233 Existing Placement Area

180A New or Extended Placement Area Under Proposed DMMP

221 Placement Areas Excluded From Proposed DMMP

LAGUNA MADRE EIS

Figure 1-2d
Placement Areas
Laguna Madre

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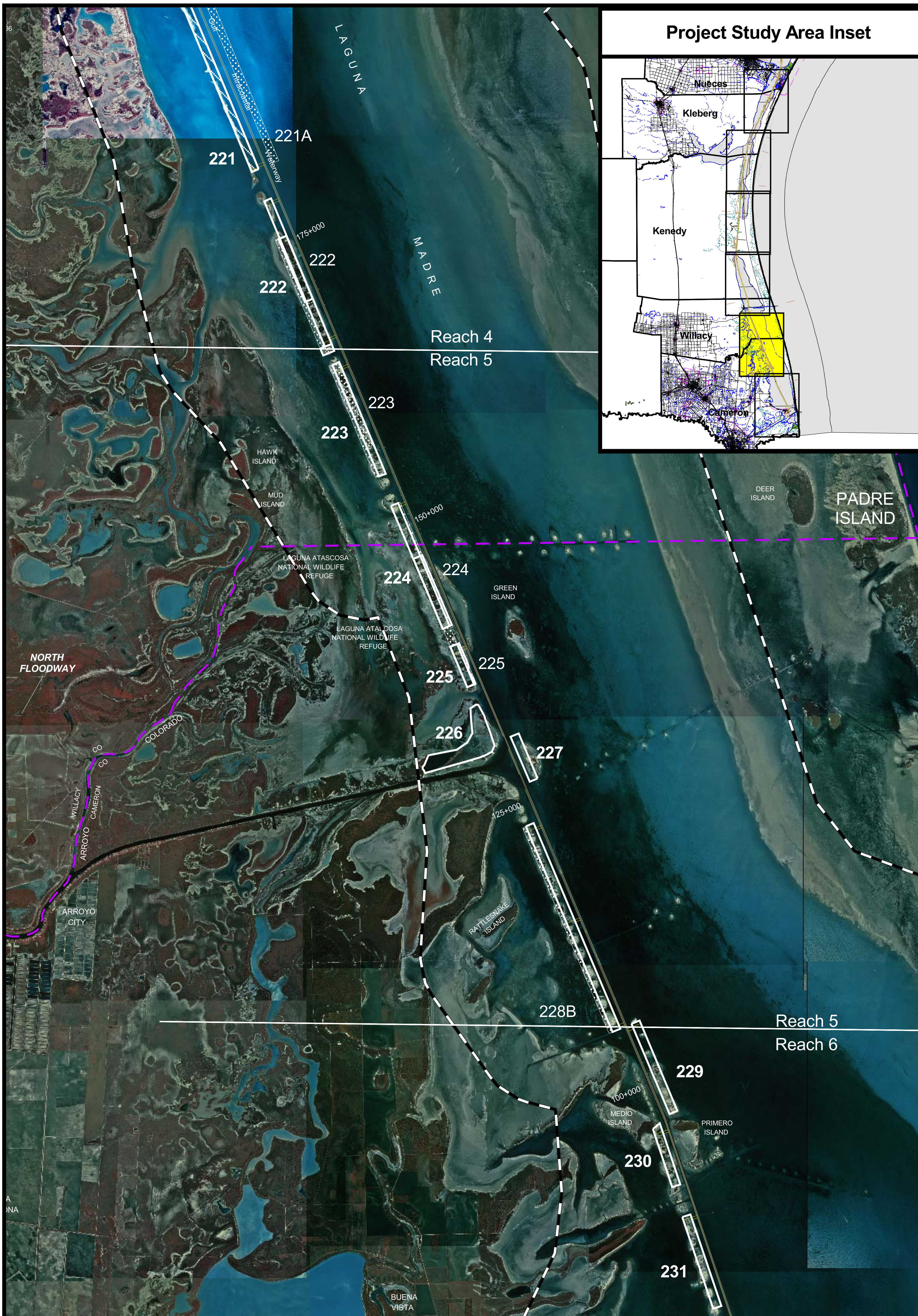

County Line

Project Area

1 0 1 Mile

8000 0 8000 Feet

233 Existing Placement Area

180A New or Extended Placement Area Under Proposed DMMP

221 Placement Areas Excluded From Proposed DMMP

LAGUNA MADRE EIS

Figure 1-2e
Placement Areas
Laguna Madre

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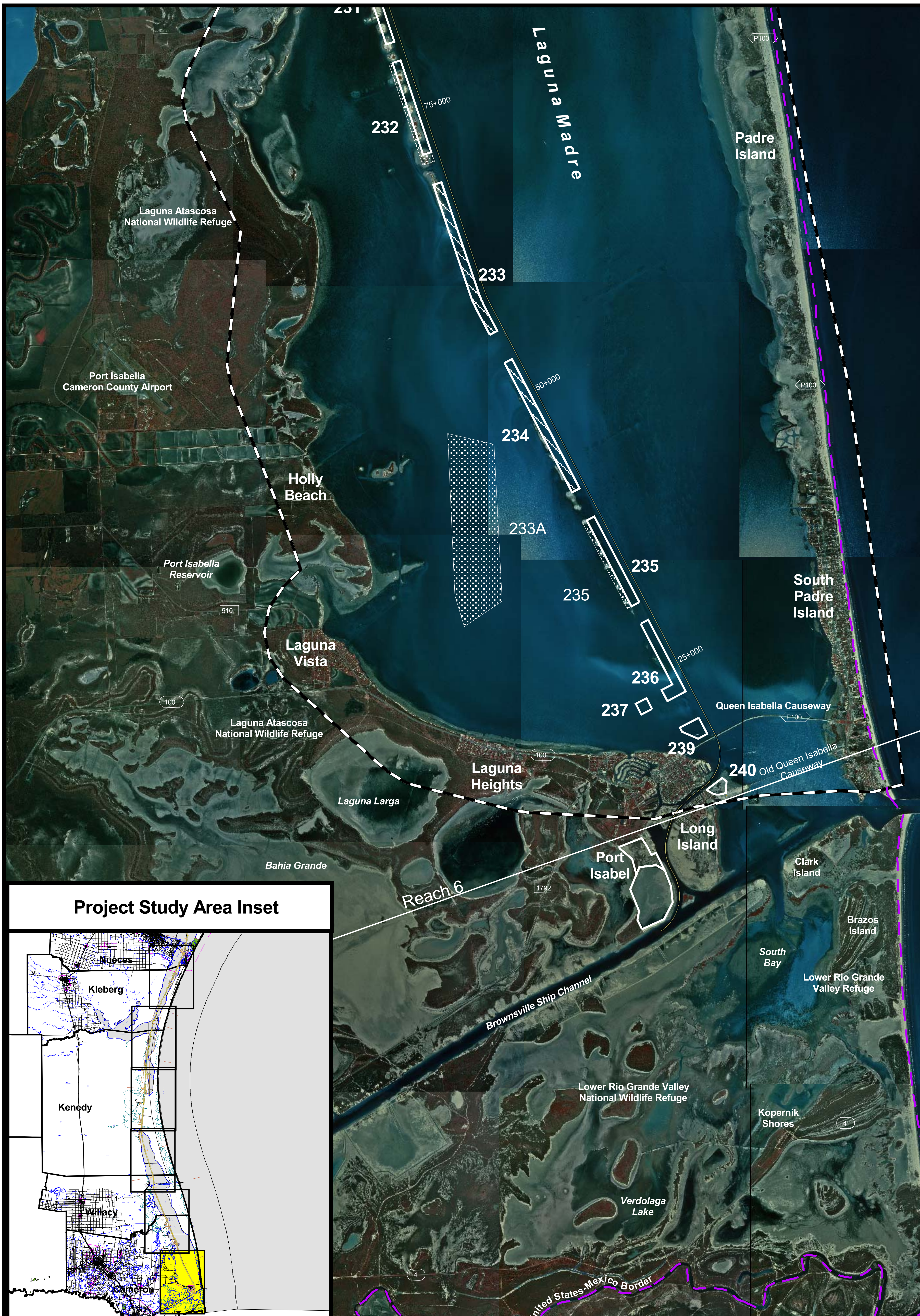

N W E S

County Line

Project Area

1 0 1 Mile

8000 0 8000 Feet

233 Existing Placement Area

180A New or Extended Placement Area Under Proposed DMMP

221 Placement Areas Excluded From Proposed DMMP

LAGUNA MADRE EIS

Figure 1-2f
Placement Areas
Laguna Madre

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the only inland waterway transportation route between the central and lower coastal areas of Texas (USACE, 1975).

1.4 PROBLEMS AND NEEDS

The current dredged material placement practice for the Laguna Madre section of the GIWW, as defined for this FEIS, consists primarily of unconfined open-bay placement with upland placement where it crosses the Land Cut and a few other areas, notably near the mouth of the Arroyo Colorado. As noted above, the main channel through the Laguna Madre has 63 PAs available, of which 61 are intermittently utilized. These sites directly impact over 9,000 acres (ac) of bay bottom (USACE, 1994). Since the publication of the 1975 EIS, several environmental organizations have raised concerns about the environmental effects of open-water placement practices and the level of analyses conducted in preparation of the original report.

As presented in Section 1.2, the 1994 Reconnaissance Report focused on navigation problems, environmental and cultural resource concerns, restoration measures, long-term disposal options, and potential rerouting of the Channel near Port Isabel. The revision of the report, in 1997, resolved issues and determined there was no Federal interest in a channel realignment plan at Port Isabel. Additional information gathered from the resource agencies, stakeholders, and the general public was combined with problems previously identified in the operation of the GIWW by the USACE and others to establish a list of the primary concerns that should be addressed during the study process in the Laguna Madre segment of the GIWW. The major concerns identified were:

- the documentation of significant resources of the entire Laguna Madre complex,
- an assessment of how current and future maintenance dredging practices will impact these resources,
- an analysis of how existing maintenance dredging practices can be modified to sustain and restore area resources,
- an estimate of the economic benefits of the existing waterway,
- an analysis of various restoration measures which could be undertaken to offset past dredging impacts to the area, and
- an assessment of studies that should be initiated to address significant portions of the above issues.

The primary concerns outlined above can be further broken down into several key components. Dredging and dredged material placement have the potential to impact the following categories:

- Water and sediment quality
- Coastal community types
- Finfish and shellfish resources
- Wildlife resources
- Threatened and endangered species

- Hazardous, toxic, and radioactive wastes
- Cultural resources
- Socioeconomic resources

The following discussion highlights the major problems associated with each of these topics.

1.4.1 Water and Sediment Quality

The primary water quality concerns for the Laguna Madre include water exchange and inflows, salinity, water chemistry, and brown tide (*Aureoumbra lagunensis*). Because the GIWW is used by commercial barges carrying petroleum products and other cargo, petroleum industry supply vessels, shrimp boats, and recreational boats, the potential exists for the spill of contaminants. Excess turbidity from dredging and placement activities has also been cited as an area of concern. A key water quality parameter critical to the productivity of the Laguna Madre is salinity. Salinity concerns include the impact that continued dredging or lack of dredging will have on salinity in the system and, subsequently, aquatic productivity. Another concern is the presence of the brown tide and the impacts associated with this phenomenon, including long-term light reduction, the alteration of food webs, and the release of NH_4^+ by dredging activities.

The sediment quality component consists of sediment chemistry, toxicity, and sediment transport. The same concern for the spill of contaminants into the water column exists with the potential for accumulation in sediment. The accumulation of certain contaminants in the sediment of the system can cause toxicological effects on aquatic organisms. Another concern raised is sediment transport, especially the transport of dredged material back into the GIWW.

1.4.2 Coastal Community Types

Coastal community types refer to seagrasses, or submerged aquatic vegetation (SAV); coastal wetlands; sand flats, mud flats, and algal flats; open-water and reef habitat; and coastal shore areas, beaches, and sand dunes. A key concern with dredging and dredged material placement activities is the potential impact to SAV communities, an important component of the Laguna Madre ecosystem. This was a strong focus of the ICT. An SAV modeling subgroup of the ICT was developed specifically to address these concerns. Additional concerns for special aquatic habitat include the filling of large areas of open-bay bottom habitat, and potential erosional problems for coastal wetlands, shore areas, beaches, and dunes with increasing barge traffic in the GIWW. Another concern frequently raised is the compartmentalization of the bay with placement areas. However, the opportunity exists to create SAV habitat with dredged material.

1.4.3 Finfish and Shellfish Resources

The aquatic faunal component of the Laguna Madre system can generally be divided into three categories: nekton, plankton, and benthos, and includes recreational and commercial finfish and shellfish. Concerns have been raised over possible adverse impacts to aquatic resources either by direct placement or by resuspension of contaminants from dredging and placement activities. A key concern and focus of the ICT was on impacts to benthic communities with respect to the placement of dredged material either directly on the community or in the vicinity. Potential impacts to commercial and recreational fisheries have also been a noted concern from stakeholders.

1.4.4 Wildlife Resources

The wildlife resource component of the existing project is fairly small, since the majority of placement activities to date have involved open-water placement. The primary concern regarding impacts to wildlife resources is the placement of maintenance material on rookery islands either displacing habitat or creating land bridges that could lead to increased predation. Conversely, a need has been expressed to enlarge some resting or rookery sites that have eroded. Other impacts to wildlife resources could occur with respect to erosional impacts to coastal wetland, shore, and dune habitats.

1.4.5 Threatened and Endangered Species

The piping plover (*Charadrius melodus*) is a winter resident in the project area, leaving in April–May and returning in July–August. Special studies (see Appendix H) sponsored by the USACE, with the advice of the ICT, were conducted to evaluate the effects of dredged material placement on the ecology of the piping plover. The efforts were focused on understanding how plovers use coastal habitats and how they react to the placement or removal of placement areas. In addition, the entire breeding population of whooping cranes (*Grus americana*) migrates to and winters in the prairies, salt marshes, and bays along the Texas coast, although considerably north of the project area. The green (*Chelonia mydas*), Kemp's ridley (*Lepidochelys kempii*), and loggerhead (*Caretta caretta*) sea turtles have been recorded within the Laguna Madre. Critical habitat for piping plover wintering grounds was designated in 2001 in Texas by the FWS (66 FR 36074–36078). All or portions of Units TX-2 to TX-5 (Figure 3-3) are within the study area for the FEIS.

1.4.6 Hazardous, Toxic, and Radioactive Wastes

As discussed in Section 4.8, the review of available data and a visual reconnaissance indicated minimal risk of the presence, or potential presence, of hazardous, toxic, and radioactive wastes (HTRW) sites within the Laguna Madre (Espey, Huston & Associates, Inc. (EH&A), 1995a). The primary concern that has been raised is the potential for marine transportation and shipping-related spills in the GIWW.

1.4.7 Cultural Resources

The historic resources component of this project includes the cultural history of the project area and identifying potential shipwrecks associated with new placement areas. There is a rich cultural history along the lower Texas coast with a great deal of activity surrounding the Corpus Christi and Brownsville areas. However, since the concerns of the ICT are with maintenance dredging and placement practices in the Laguna Madre from the JFK Causeway to the old Queen Isabella Causeway, both Corpus

Christi Bay and the Brownsville area are outside the project area and will not be addressed. However, in the event that a new placement area would be developed, the potential exists for identifying shipwrecks during studies at those sites.

1.4.8 Socioeconomic Resources

This component includes potential impacts to population and employment, commercial and recreational fishing, recreation and tourism, waterborne transportation, land use, and maintenance dredging. Two major concerns raised involve an economic justification for keeping the GIWW open and the counter view of economic impacts of closing the GIWW. The two concerns directly relate to each of the components listed above. Problems associated with changes in waterborne traffic would include safety issues, collisions, accidents, and spills.

1.5 PUBLIC AND AGENCY CONCERNS

Several environmental groups, agencies, and landowners have questioned the environmental effects of the open-bay placement practice described in the 1975 EIS and whether the EIS adequately addressed such effects. These groups have included the Gulf Intracoastal Waterway Maintenance Dredging Working Group (the Working Group), the LLM Foundation, the King Ranch, and the National Audubon Society.

The Gulf Intracoastal Waterway Advisory Committee (GIWAC) was formed in January 1984 by the State to oversee its effort of providing placement areas for the GIWW. The GIWAC is an interagency committee consisting of representatives of the various State agencies. This committee has formed several task forces composed of Federal and State resource agencies, TxDOT, and the USACE to locate and evaluate potential placement areas for dredged material.

In 1986, a GIWAC task force was formed because of continued concerns over SAV impacts from dredging operations, increased predation of colonial waterbird rookeries on existing placement areas, and other impacts from open-bay placement of dredged material. The consensus of the Federal and State agencies was to use upland placement, and three sites were selected on the Padre Island National Seashore (PINS). A public notice was issued and the preparation of an Environmental Assessment (EA) was initiated. In July 1989, the NPS formally withdrew the option of using these three upland sites, citing management mandates and legislative constraints.

The question of the inadequacy of the EIS was first raised in 1989 when the Working Group challenged various portions of the existing EIS as to its compliance with various environmental statutes. The Working Group comprised representatives from the FWS, NMFS, NPS, GLO, and TPWD. Their issue paper, entitled "Evaluation of the U.S. Army Corps of Engineers' 1975 Environmental Impact Statement on Maintenance Dredging of the Gulf Intracoastal Waterway – Texas Section," recommended a new EIS be prepared to comply with the most recent environmental statutes.

A significant portion of the Reconnaissance Study initiated by the USACE in 1993 was to solicit and compile public, stakeholder, and resource agency input and to stimulate involvement. The resource agencies, including FWS-Corpus Christi, NMFS, TPWD, and GLO, were requested to provide input on critical resources within the project area and identify environmental issues and concerns associated with dredging and dredged material placement in the Laguna Madre.

The USACE Galveston District also distributed a public notice in October 1993 to notify the public and stakeholders and asked for problem identification input. A series of public workshops were held in Kingsville, Harlingen, and Port Isabel on December 7, 8, and 9, 1993, respectively. In addition, the FWS prepared a Planning Aid Report describing the baseline conditions of the project area for the USACE Galveston District. The information gathered during these activities was combined with problems previously identified by the USACE and others and incorporated into a list of primary concerns. The general components are described in Section 1.4. A summary of public and agency concerns is presented below:

Dredging/Placement Concerns:

- Discontinuing open-bay placement
- Impacts on future development of upland areas
- Condemnation and use of King Ranch property for placement
- Need for 50-year disposal plan
- Mud flow impacts to aquatic sites outside authorized placement areas
- Improved cleanup after dredging operations
- Marking placement islands
- Filling bay bottoms with dredged material
- Effects of dredged material placement on fish and wildlife and their habitats
- Compartmentalization of the bay with placement areas
- Sedimentation of dredged material into the GIWW

Environmental Concerns:

- Need for an updated Environmental Impact Statement
- Contaminants and water quality
- Increased predation due to placement of dredged material on rookery islands
- Impacts to commercial fishing
- Turbidity during dredging
- SAV losses
- Hydrology of the bay
- Impacts of dredged material on benthic communities
- Effects of the Arroyo Colorado/Channel to Harlingen on the Laguna Madre

Economic Concerns:

- Economic justification for this reach of the GIWW
- Economic impacts of GIWW closure

Safety:

- Shipments of hazardous commodities
- Barges running aground
- Doubling and tripling of barge traffic in the GIWW

1.6 INTERAGENCY COORDINATION TEAM

An ICT was established in 1995 to help the USACE accomplish the goal of developing scientific investigations to address environmental concerns raised by resource agencies and environmental groups. More information about the ICT, including its charter, can be found in Appendix H. The ICT is composed of representatives from TxDOT, GLO, Texas Commission on Environmental Quality (TCEQ), TPWD, Texas Water Development Board (TWDB), NMFS, U.S. Environmental Protection Agency (EPA), FWS, and USACE, all of which had one vote. There were also two advisory members: PINS, and Coastal Bend Bays and Estuaries Program (CBBEP). Two of the goals of the ICT were to help develop the scopes of work for the environmental studies and to review and critique the study results. The ICT met for the fist time in February 1995 and has met at scheduled intervals throughout the project. This includes 27 ICT meetings, four Modeling Workshops, seven DMMP Workshops, and one Cost Analysis Workshop. The purpose of the ICT was to assist in the development of the environmental documentation for the project that will fully address the environmental concerns for the continued maintenance and operation of the GIWW in the Laguna Madre. Toward this effort, the ICT 1) has assisted the USACE in the development and implementation of the scopes of work for the scientific investigations; 2) has reviewed drafts of the scientific investigations, the DMMP, and FEIS; and 3) will provide a forum for continued coordination on the preferred alternative (DMMP) through the life of the project and provide advice on modifying management plans for the placement areas. Determination of the studies to be performed was normally by consensus. On the rare occasions when consensus could not be achieved, a majority of the voting members allowed for a decision.

Appendix H provides a detailed review of the various studies funded by the USACE. These included:

1. reviews of available information on the water and sediment quality of the Laguna Madre and tributary systems,
2. chemical analyses and bioassays of maintenance material collected from the GIWW through the Laguna Madre,
3. a sophisticated depth profile and bottom classification of the Laguna Madre,
4. analysis of a multi-year data collection effort needed as input for the models,

5. analyses of the effect of past placement of dredged material on benthic organisms and their habitat and fish habitat,
6. a complete sediment budget analysis for the Laguna Madre,
7. the hydrographic and sediment transport models and the seagrass models that were designed to answer critical questions about impacts to seagrasses from dredged material placement,
8. economic analyses of the GIWW in the Laguna Madre and the economic impact of its closure on the region, and
9. studies on piping plover habitat in the Laguna Madre and the impact of dredged material placement on piping plovers.

1.7 ENVIRONMENTAL CRITERIA

The general environmental criteria for navigation projects are identified in Federal environmental statutes, executive orders, and planning guidelines. It is a national policy that fish and wildlife resources conservation be given equal consideration with other study purposes in the formulation and evaluation of alternative plans. The basic guidance during planning studies is to insure that care is taken to preserve and protect significant ecological, aesthetic, and cultural values and to conserve natural resources. These efforts also should provide the means to maintain and restore, as applicable, the desirable qualities of the human and natural environment. Alternative plans formulated to improve navigation should avoid damaging the environment to the extent practicable and contain measures to minimize or mitigate unavoidable environmental damages. Particular emphasis should be placed on:

1. protection, preservation, and improvement of the existing fish and wildlife resources along with the protection and preservation of estuarine and wetland habitats and water quality;
2. consideration in the project design of the least disruptive construction techniques and methods;
3. mitigation for project-related unavoidable impacts by minimizing, rectifying, reducing or eliminating, compensating, replacing, or substituting resources;
4. protection and preservation of endangered and/or threatened species; and
5. preservation of significant historical and archeological resources through avoidance of effects. This is the preferable action to any form of mitigation since these are finite, nonrenewable resources.

These criteria were applied to the DMMP to address environmental impacts for various alternatives and to assess possible mitigation features to offset unavoidable impacts.

1.8 RESOURCE MANAGEMENT OPPORTUNITIES

Opportunities were explored in consultation with State and Federal resource agencies to beneficially use dredged maintenance material to create, restore, or enhance the environment in the project area. Restoration of SAV coverage and species distribution, especially in deeper waters and areas near designated open-water placement areas, has a high priority among resource agencies. The system is dependent on SAV for its principal source of primary productivity in a low-nutrient environment that has not developed the salt marshes that are more familiar along the upper Texas coast. In addition, SAV in the Laguna Madre represents a scarce and unique resource because its abundance decreases farther up the Texas coast as water turbidity increases and deeper depths prevent its natural establishment.

A large-scale restoration plan was investigated in the Reconnaissance Study to modify salinity conditions on both the ULM and LLM. Restriction of circulation between the ULM and LLM would allow restoration of the Laguna Madre to a higher salinity condition. This higher salinity condition is more conducive to the growth of shoalgrass (*Halodule wrightii*) than the other seagrass species. However, the salinity in the ULM and LLM would have to be closely monitored to prevent a return to the hypersaline conditions that were prevalent before the GIWW was constructed and which would inhibit or prevent growth of all seagrass. It was concluded that controlling circulation and salinity in the GIWW as it traverses the Laguna Madre as a means of influencing SAV survival and composition meets the criteria for ecosystem restoration. However, this idea was dropped during the Section 216 study because of agency concern for other unintended consequences and the public view that this measure is not desirable.

Continued discussion with the resource agencies in the early sessions has led to the production of a list of additional restoration measures to correct localized problems. These potential measures include:

1. The removal of selected emergent disposal islands that are too close to the mainland, the barrier island, or other islands. These islands allow terrestrial predators, such as coyotes and raccoons, access to larger islands that are used as rookeries by colonial waterbirds. Removal of these islands would allow the colonies to expand to several islands previously abandoned because of heavy predation, especially near the PINS.
2. Dredging of circulation channels between several emergent unconfined placement areas. Dredged material has filled in the shallow areas around some placement areas, isolating several small bays from the Laguna Madre. Better circulation in the area could potentially restore productivity in these bays.
3. Enlarging one or two of the disposal islands located around Mile 615 south of the Land Cut (PA 212). These islands are experiencing erosion. If enlarged, these islands could be used as nesting islands for colonial waterbirds.
4. Armoring PA 220 located on the northeast side of the intersection of the GIWW and Port Mansfield Channel. This restoration measure would protect this unconfined placement area, an important bird nesting island, from further erosion.

2.0 ALTERNATIVES

2.1 INTRODUCTION

This section discusses the alternatives considered during the preparation of the DMMP, including those that were eliminated from further study, those considered in detail, and, for comparative purposes, the No-Action alternative. Also discussed is the approach that was used to develop the range of alternatives and to eliminate or refine them. All alternatives raised by the ICT, stakeholders, and the public were initially included. The next paragraph and sections 2.2 through 2.9 discuss the early process by which the ICT developed a matrix for scoring alternatives and the results of that process. Some of the information has changed from refined analysis and further investigations and this updated information is included, as necessary, in the sections after 2.9. However, the original data were left in sections 2.2 through 2.9 so that the reader can see the data that were available to the ICT in the matrix process. After much deliberation, the ICT ultimately determined that a PA by PA approach for dredged material management was necessary, which resulted in the DMMP included in Section 2.11.

The ICT recommended that the Laguna Madre be broken into sections to facilitate the preparation and examination of the matrix analysis. It was felt that having one large matrix for all of the Laguna Madre would not allow the ICT to achieve any specificity in the DMMP. On the other hand, breaking the Laguna Madre into too many divisions would make the number of matrices so large that work on the DMMP would progress to slowly. Therefore, after much debate a compromise was reached to subdivide the Laguna Madre into six reaches. Supporting data, provided in Section 2.3 below, indicated that there were six relatively homogeneous regions into which the Laguna Madre could be conveniently subdivided and the ICT determined that six sets of matrices was a manageable number.

A matrix was developed which used a point system, or scores, for the impact of a particular placement option (e.g., offshore, upland, open bay, etc.) on particular impact receptors (e.g., threatened and endangered species, waterfowl and wading birds, benthos, terrestrial flora, groundwater, hydrology, navigation hazards, etc.). Each receptor was evaluated objectively and independently by the ICT to achieve quantifiable and repeatable results. By combining the impact scores for the various scenarios on the receptors, the alternatives were ranked to produce a fully justified, numerically derived preferred alternative per reach, so that no alternative was excluded based on a single criterion, nor did any criterion dominate the ranking process. The development of the screening criteria, the alternatives matrix, the point systems, and the reasoning behind them are presented in detail below.

2.2 NO-ACTION ALTERNATIVE

The No-Action alternative is the base condition from which all other alternatives are compared. The purpose of this alternative is to forecast the most probable future of the study area, usually over the project's 50-year economic life without the project. For new projects, this alternative would forecast the future of the study area as if the project were not in place. However, the GIWW is an existing project that was authorized by Congress and constructed over 50 years ago. Therefore, the No-Action alternative represents the base condition with the GIWW in place and maintained by present dredging and placement methods. Furthermore, since it is an existing project, the baseline condition cannot be projected backward to the pre-GIWW period (prior to 1949). Another reason for not using a "without project" condition for no action is that it does not meet the underlying purpose and need of the NEPA assessment which is to update existing information and provide additional information and environmental analysis concerning dredged material placement from continued maintenance dredging of the GIWW through the Laguna Madre. Also, since the Section 216 study did not find a Federal interest in changing the dimensions, location, or terminating the project, the project does not need to go before Congress for reauthorization or deauthorization. Thus, the options remaining for consideration in this study are to resolve the environmental problems associated with present dredged material placement practices.

Based on these considerations, the forecast of future conditions with the project in place will provide the environmental baseline to compare all other alternatives for economic benefits and environmental impacts. The purpose of these comparisons is to clearly and accurately describe project-related economic and environmental benefits and costs so project decision-makers at all levels will be fully aware of the environmental consequences of their actions.

There was no Federal interest in abandoning or deauthorizing the GIWW since it is an important, safe, low-cost means of transporting goods along the Texas coast and it links the coastal ports with the vast national inland waterway network. The reach of the GIWW through the study area is an important link in the waterway that connects the upper Texas coast with its many petroleum-related, agricultural, and other manufacturing industries to the Rio Grande Valley. If this link were broken, about 2.25 million tons of commodities would be forced to find alternative means of transport (see Appendix H, Section 3.12.2.3, and Section 4.13 for more details on an alternative modes analysis).

2.3 DEVELOPMENT OF REACHES

It was recommended by the ICT that the effectiveness of the matrix analysis would be affected by how well the various impact receptors were described for each of the reaches. Therefore, the reaches needed to be defined such that the various impact receptors were fairly similar within a given reach without creating too many reaches. Although there were many factors to consider, the concern over the potential vulnerability of seagrass beds and benthic communities to dredging activities made them very important to the development of the reaches.

There are three obvious geographic breaks in the project area: the ULM, the LLM, and the Land Cut. The geography of many features corresponds to these breaks or varies (requiring further breakout) within each of the three. The ULM is generally shallower and sandier than the LLM (USACE, 1998; White et al., 1983, 1986, 1989). It is also more saline (Quammen and Onuf, 1993, White et al. 1983, 1986, 1989), which impacts several traits, including vegetation, benthic and nektonic communities (Sheridan, 1998, 1999; White et al., 1983, 1986, 1989). In general, the ULM is biologically less diverse than the LLM. The seagrass beds are predominantly shoalgrass in the ULM, while other SAV species are recognizable in the LLM (FWS and TPWD 1988–94). Benthic communities are less diverse in the ULM than in LLM, with the highest diversity in the southern part of LLM near Brazos Santiago Pass (EH&A,

1998b; White et al., 1986, 1989). Other characteristics that may indicate the need for separate reaches are water and sediment quality and tissue data that in a few locations have indicated causes for concern with respect to metals, excess nutrients and/or pesticides (DDT, chlordane). These areas are the Arroyo Colorado, Baffin Bay, Port Mansfield and Port Isabel (EH&A, 1997a; Davis et al., 1996; Barrera et al. 1995; Stockwell et al., 1993; Warshaw, 1975). Brown tide, when present, tends to be more prevalent in the ULM (DeYoe et al., 1997; Buskey et al., 1996; Barrera et al., 1995; Whitledge, 1993).

These data supported the division of reaches in the following way. First, the project area was broken into three major segments: the ULM and LLM and the Land Cut. The ULM was further divided into two reaches: 1) the northern end, which would be more affected by the proximity of Corpus Christi Bay; and 2) Baffin Bay and the southern end. This separates the deeper areas of the southern ULM (many too deep for seagrasses) from the broad shallow shelf to the north. It also separates the water quality concerns associated with Baffin Bay from the northern end where currents and proximity to the connection with the Gulf of Mexico increase circulation. This subdivision also roughly separates the areas where the GIWW is closer to the mainland in the southern part of the ULM from the section closer to the barrier island to the north.

The two ends of the LLM are very distinct. The northernmost section has higher salinity and supports less diverse benthic communities than the southern part (White et al., 1986, 1989). Also, much of the area that the GIWW traverses is in waters too deep to support seagrasses. The southernmost reach has lower salinities and is influenced by the Brazos Santiago Pass. It supports the most diverse benthic communities of the Laguna (White et al., 1983, 1986, 1989) and in this reach, the GIWW goes through some of the deeper parts of the Laguna and crosses a long stretch of unvegetated bay bottom. It is an area that requires a high frequency of maintenance dredging (Brown and Kraus, 1997).

There is reason for a third, intermediate reach within the LLM, associated with the Arroyo Colorado. The use of three subdivisions allows Port Mansfield, the Arroyo Colorado and the Port Isabel/South Padre Island areas, each with their own water quality issues, to be in separate reaches. The Arroyo Colorado is part of the central region. In this reach, the GIWW traverses shallower waters, in part, adjacent to the mainland and, in general, has finer-grained substrate than the other reaches. Also, the shoreline of the LANWR lies wholly within this one reach.

This analysis creates six reaches with lengths ranging from 11–25 miles. These are reasonable lengths for individual assessments. These divisions should allow adequate consideration of local characteristics and concerns without creating too many reaches, which would be less practical for both data compilation and analysis.

The following six reaches are designated for the project area (see Figure 1-1). Placement area numbers and Channel Stations are from the USACE (Table 2-1).

TABLE 2-1

REACHES

Reach	Reach Description	PA No.	Channel Station*	Statute Mile**	Length (miles)
1	John F. Kennedy Causeway (Corpus Christi) to northern side of Baffin Bay	175–191	27+000–126+900	553–572	19
2	Northern border of Baffin Bay to northern boundary of the Land Cut	192–202	126+900–216+165	572–588	16
3	Land Cut	203–210	216+165–327+739, 319+200–297+400	588–612	24
4	Southern boundary of the Land Cut to south of Port Mansfield	211–222	297+400–165+000	612–638	25
5	South of Port Mansfield to south of Arroyo Colorado Cutoff	223–228	165+000–105+000	638–649	11
6	South of Arroyo Colorado Cutoff to old Queen Isabella Causeway location (Port Isabel)	229–240	105+000–18+000	649–665	16

* Channel station numbers are from two series of numbers. In the ULM, numbers increase from north to south. In LLM, numbers increase from south to north.

** Statute miles were taken from NOAA Nautical Charts and are based on zero at Harvey Lock, LA.

The reaches were broken into smaller divisions, designated as segments, to prevent the distance from the dredge to various placement areas from exceeding 7 miles. There are several reasons for this division. This segmentation is considered a mechanically feasible distance for pumping. For example, the maximum pumping distance for beach nourishment at Galveston, along Seawall Boulevard, was roughly 7 miles. However, this pumping distance was achieved with a 34- to 36-inch dredge, and as can be determined from the following table (Table 2-2) of pumping distance versus dredge size, a 20- to 24-inch dredge, which is able to work the GIWW, cannot achieve this pumping distance without boosters. There are parts of the Laguna where the distance from the GIWW to the shoreline is roughly 4 miles. This allows only a 6-mile stretch of the GIWW (3 miles on either side of the point at which the pipeline goes toward shore) to be dredged per Upland Confined Placement Area. Therefore, a pumping distance shorter than 7 miles would require an inordinate number of upland placement areas.

Only a 24-inch dredge can achieve much production, even at 2 miles. Boosters are basically dredges without the suction head, but there is roughly a 10 percent loss of volume for each booster used, so stringing more and more boosters in series does not maintain production. In practice, even a series of a few boosters reduces production so much, while increasing plant cost, that it no longer is feasible.

TABLE 2-2

PRODUCTION RATE VERSUS PUMPING DISTANCE FOR VARIOUS DREDGE SIZES

Dredge Size (inches)	Pumping Distance (feet/miles)	Production Rate (cubic yards/hour)
20	4,520/0.9	800
	9,040/1.7	520
	12,995/2.5	220
22	4,500/0.9	1,000
	9,000/1.7	650
	13,000/2.5	280
24	5,650/1.1	1,200
	11,300/2.1	780
	15,820/3.0	330

2.4 EVALUATION CRITERIA/RECEPTORS

The approach recommended by the ICT involved the development of a matrix which 1) clearly presents the reasoning behind the numerical rankings and 2) clearly presents the advantages and disadvantages of each alternative to each impact receptor.

At an early meeting (September 1999), the ICT developed 22 evaluation criteria or receptors. At subsequent meetings, those 22 evaluation criteria were synthesized into eight Resource Categories, as shown in the following table (Table 2-3), but only six were analyzed since endangered and threatened species were included in the first eight, and cost was not a factor in the analysis.

TABLE 2-3

RESOURCE CATEGORIES

Resource Category	Original Evaluation Receptors
Submerged Aquatic Vegetation	Aquatic Flora
Open-Bay Bottom (excluding seagrass)	Benthos Beneficial Uses
Emergent Bay Habitat	Benthos Beneficial Uses Tidal Flats Waterfowl/Wading Birds Wetlands
Terrestrial Habitat	Beneficial Uses (sediment quality, location, recreational fisheries) Terrestrial Flora – Wetlands/Uplands Terrestrial Fauna

TABLE 2-3 (Concluded)

Resource Category	Original Evaluation Receptors
Water Column Effects	Nekton Plankton Water Quality – Turbidity/Toxicity Circulation
Human Use Effects	Air Quality/Noise Navigation Hazards Historical Resources Commercial/Recreational Fisheries
Endangered and Threatened Species	The impacts on E & T Species should be considered for all relevant criteria. For example, the impact to endangered sea turtle species is reflected in the scoring of the impact to their habitat, in this case, primarily seagrass beds.
Cost	Dredging/Placement Costs Reduce Frequency of Maintenance Time – ability to meet GIWW maintenance schedule

2.5 PLACEMENT ALTERNATIVES

At the same series of meetings noted in Section 2.4, the following placement alternatives were recommended by the ICT for further consideration:

1. Open Ocean/Offshore Placement
   a. Hopper Dredges
   b. Pipeline Dredges and Scows
   c. Pipeline Dredges and Pipelines
2. Upland Placement
   a. Confined Upland Placement
   b. Thin layer Placement
3. Beneficial Uses
   a. Beach Nourishment
   b. Washover Nourishment
4. Open-Bay Placement
   a. Open-Bay Unconfined
   b. Open-Bay Confined
   c. Open-Bay Semiconfined

2.6 SCREENING CRITERIA

The ICT recommended early in the evaluation process that, while the list of alternatives for each reach would include essentially all possibilities, it would be prudent to develop screening criteria and apply these first, rather than expend extensive resources and time investigating all alternatives, including those that were not feasible. These screening criteria provide a fatal flaw analysis, such that if any of the screening criteria were not met, the placement option would not be feasible and, therefore, would not be subject to evaluation. The screening criteria were three:

- Meet Engineering Feasibility – For example, a hopper dredge that was too tall to fit under the JFK Causeway could not be used for ocean placement of material from Reaches 1 through 4.
- Meet Federal Requirements – For example, pipelines across the PINS are not allowed by the NPS and, therefore, an alternative that required pipelines across the PINS would not meet the Federal Requirements Screening Criterion.
- Meet State Requirements – For example, if an alternative allowed the release of a discharge that violated TCEQ Water Quality Standards or if an alternative was not in compliance with the Texas Coastal Management Program, that alternative would not meet the State Requirements Screening Criterion.

Table 2-4 presents the application of the Screening Criteria to each Placement Option, by Reach.

Open ocean placement by hopper dredges did not meet the Engineering Feasibility Screening Criterion for any reach. This is because, as noted in Section 2.9.2.1, these dredges cannot turn around in the GIWW and the ICT did not consider it to be environmentally acceptable to allow dredging of numerous turnaround basins in the Laguna Madre. This alternative would require each hopper dredge to transit the length of the GIWW between each of the three entrance channels (Corpus Christi, Port Mansfield, and Brazos Island Harbor), depending on which reach was being dredged. Therefore, as an examination of Section 2.9.2.1 reveals, this option would require an average of 18.6 dredges in the GIWW between, and in, the Corpus Christi Ship Channel and the Port Mansfield Channel 24 hours per day at all times to remove the maintenance material. There would be an average of 3.1 dredges in the GIWW between the Brazos Island Harbor Channel and the Port Mansfield Channel and in the two ship channels 24 hours per day at all times. These two combined would yield a minimum of 21.2 dredge trips/day or 7,738 trips/year in the GIWW through the Laguna Madre, just to keep up with the sediment that accumulates in the GIWW. This assumes that needs for maintenance dredging in the various reaches could be accomplished using the fewest possible dredges and that this number of dredges could be located and made available. The latter assumption is not engineeringly feasible since that number of hopper dredges, of all sizes, is not available, and certainly not of the small size which could be used in the GIWW (USACE data). For example, Great Lakes Dredge and Dock Company, a major dredging firm, listed only seven trailing suction hopper dredges on their website (www.gldd.com in 1999), and none of these were as small as those used for the analysis in Section 2.9.2.1.

TABLE 2-4

APPLICATION OF SCREENING CRITERIA

		Placement Options									
		Upland		Open Ocean / Offshore			Beneficial Uses		Aquatic		
		Confined Upland	Thin Layer	Hopper Dredges	Cutterhead Suction Dredge and Scows	Cutterhead Suction Dredge and pipelines	Beach Nourishment	Washover Nourishment	Open Bay / Unconfined, existing PAs only	Confined	Semi-confined
REACH # 1									+		
Screening Criteria	Engineering Feasibility	Y	Y	N	N	Y	N	N	Y	Y	Y
	Meet Federal Requirements	Y	Y	Y	Y	N*	N*	N*	Y	Y	Y
	Meet State Requirements	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
REACH # 2									+		
Screening Criteria	Engineering Feasibility	Y	Y	N	N	N	N	N	Y	Y	Y
	Meet Federal Requirements	Y	Y	Y	Y	N	N	N	Y	Y	Y
	Meet State Requirements	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
REACH # 3		+									
Screening Criteria	Engineering Feasibility	Y	Y	N	N	N	Y	Y*	Y	Y	Y
	Meet Federal Requirements	Y	Y	Y	Y	N	N	N	Y	Y	Y
	Meet State Requirements	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
REACH # 4									+		
Screening Criteria	Engineering Feasibility	Y	Y	N	N	N	N	N	Y	Y	Y
	Meet Federal Requirements	Y	Y	Y	Y	N*	N*	N*	Y	Y	Y
	Meet State Requirements	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
REACH # 5									+		
Screening Criteria	Engineering Feasibility	Y	Y	N	N	Y	N	N	Y	Y	Y
	Meet Federal Requirements	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Meet State Requirements	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
REACH # 6									+		
Screening Criteria	Engineering Feasibility	Y	Y	N	N	Y	N	N	Y	Y	Y
	Meet Federal Requirements	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Meet State Requirements	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

N* Part of Reach encompasses the National Seashore, which no pipelines can cross.
Y* Not enough washover areas to handle all material
+ Present Practice for this Reach.

Open ocean placement by cutterhead suction dredges and hopper barges (scows) failed the Engineering Feasibility Screening Criterion for all reaches, again because of a lack of sufficient equipment. As noted in Section 2.9.2.2, during all available times, three dredges and 12 scows would be needed and during 42 percent of the time, an additional dredge and four scows would be needed. This leads to a total of 2,605 trips by hopper scows, plus tugboats (covering 155,383 miles per year), through the GIWW and associated entrance channels to the Gulf of Mexico. Section 2.9.2.2 also notes that there are presently only four scows available on the Gulf Coast. The Great Lakes Dredge and Dock Company's website (www.gldd.com) only listed a total of 31 scows and 14 tugboats in 1999, some of which are too big for the GIWW. However, even if all were of the correct size, dredging the GIWW through the Laguna Madre would consume over half of the scows and more than all of the tugs.

Open ocean placement by cutterhead suction dredges, pumping through pipelines to the Gulf of Mexico, failed the Engineering Feasibility Criterion for Reaches 2, 3, and 4 because pumping distances are so great that the required number of boosters would reduce the flow to zero at the end of the pipeline (Section 2.9.2.2). It also failed the Federal Requirement Criterion for all of Reaches 2 and 3 and parts of Reaches 1 and 4 because the pipeline to the Gulf would have to cross the PINS.

Beach nourishment failed the Engineering Feasibility Criterion for all reaches, except Reach 3, because the maintenance material contains insufficient sand to be used for beach nourishment. It also fails the Federal Requirement Criterion for all of Reaches 2 and 3 and parts of Reaches 1 and 4 because the pipeline to the Gulf beach would have to cross the PINS.

Washover nourishment failed the Engineering Feasibility Criterion for all reaches because the maintenance material contains insufficient sand to be used for washover nourishment. It only partially satisfies the Engineering Feasibility Criterion for Reach 3 since there is insufficient washover area in Reach 3 to use all of the dredged material. It also fails the Federal Requirement Criterion for all of Reaches 2 and 3 and parts of Reaches 1 and 4 because the pipeline to the washover areas would have to cross the PINS.

The two upland placement options (upland confined and upland thin layer), the three open-bay options (open-bay confined, open-bay semiconfined, and open-bay unconfined), and ocean placement by pipeline (in parts of Reach 1 and all of reaches 5 and 6) met all Screening Criteria and were carried forward into the matrix analysis.

2.7 PRELIMINARY COST ESTIMATE

The matrix analysis did not put point values on cost. However, the different placement options have different costs and should these costs be very large, cost would have to be taken into account. Therefore, a preliminary cost analysis was conducted and the results are presented in Table 2-5. These preliminary costs were prepared before some of the Screening Criteria were analyzed by the ICT, so some costs are included, for information purposes, for options that have been excluded by the Screening Criteria.

TABLE 2-5

PRELIMINARY COST ANALYSIS

AVERAGE COST PER CUBIC YARD BY REACH AND PLACEMENT OPTION

9/10/03

	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
OCEAN PLACEMENT WITH HOPPER DREDGES	$57.98	$58.13	$58.05	$52.50	$31.77	$30.10
OCEAN PLACEMENT WITH PIPELINE DREDGES AND SCOWS	$21.13	$30.47	$23.91	$9.22	$15.55	$10.35
OCEAN PLACEMENT BY PIPELINE	$18.07	Not feasible	Not feasible	Not feasible	$46.63	$11.87
UPLAND CONFINED PLACEMENT, Present Practice for Reach 3	$5.63	$4.28	$0.88	$4.26	$17.24	$5.74
UPLAND, THIN SHEET	$4.48	$3.63	Not feasible	$3.29	$15.18	$4.71
OPEN BAY CONFINED Pump to "The Hole" for Reach 3	$2.10	$1.48	$2.48	$1.82	$4.37	$2.06
OPEN BAY SEMI-CONFINED	$1.39	$1.06	$1.81	$1.22	$3.09	$1.36
OPEN BAY, Present Practice for Reaches 1,2,4,5,6	$0.72	$0.66	$1.33	$0.65	$1.88	$0.74

RATIO TO PRESENT PRACTICE BY REACH AND PLACEMENT OPTION+

	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
OCEAN PLACEMENT WITH HOPPER DREDGES	69.35	76.24	56.11	69.13	14.52	35.20
OCEAN PLACEMENT WITH PIPELINE DREDGES AND SCOWS	25.27	39.96	23.11	12.13	7.10	12.10
OCEAN PLACEMENT BY PIPELINE	25.71	Not feasible	Not feasible	Not feasible	24.42	14.97
UPLAND CONFINED PLACEMENT, Present Practice for Reach 3	5.72	5.48	1.00	5.93	7.56	6.80
UPLAND, THIN SHEET	4.54	4.66	Not feasible	5.22	2.94	3.98
OPEN BAY CONFINED	2.32	1.91	2.78	2.39	1.93	2.13
OPEN BAY SEMI-CONFINED	1.69	1.48	2.25	1.74	1.50	2.58
OPEN BAY, Present Practice for Reaches 1,2,4,5,6	1.00	1.00	1.85	1.00	1.00	1.00

Cost do not include (1) EISs, or equivalent, for ocean placement; (2) land purchase/law suits for upland sites; or (3) costs for navigation changes/problems for any options.

2.8 MATRIX ANALYSIS

2.8.1 Ranking System

The ICT recommended the following guidance for scoring the various placement alternatives relative to their impact on the various Evaluation Criteria or Receptors. As shown below, the scores ranged from –3 for negative impacts to +3 for beneficial impacts, with 0 being the impact of the present placement practice for dredging the GIWW through the Laguna Madre. The present practice was considered the baseline against which all comparisons for all alternatives were made. Thus, the present practice was assigned a score of 0, not necessarily because there was no impact, but to show how each alternative differed in its impact from the present practice, either positively or negatively. The score and a description of each is as follows:

- + 3 potentially overriding benefits, thus, critical to decision making;
- + 2 significant positive improvement considering magnitude of net change and the value of the resource;
- + 1 environmentally preferable to impacts on resource than current practice;
- 0 same or equivalent impact on resource as current practice;
- – 1 environmentally less preferable impacts on resources than current practice;
- – 2 significant negative impact considering magnitude of net change and the value of the resource;
- – 3 potentially unacceptable impacts to resources.

2.8.2 Scoring Criteria

In the process of deriving the scores of the various Placement alternatives, the ICT determined that for consistency, criteria would have to be established relative to the sizes of areas impacted, quantities of various water column effects, various human use impacts, etc. that would be assigned to each of the scores presented in the previous section. The following are the results of the ICT's deliberations.

2.8.2.1 Areal Impacts

For areal impacts, such as burying seagrasses, open-bay bottom, emergent bay habitat, and terrestrial habitat, alternatives that impact less than 1 acre relative to current practices were assigned a score of 0. If the impact area was between 1 and 100 acres, relative to present practice, the alternative was assigned a score of 1. If the impact area was greater than 100 acres but no more than 1,000 acres, relative to present practice, the alternative was assigned a score of 2. For an areal impact greater than 1,000 acres, relative to present practice, the alternative was assigned a score of 3. In all cases, the score was a "+", if the impact was positive, and "–", if the impact was negative. Other examples of areal impacts are 1) the area of a receptor that would be impacted by laying and removing pipelines for upland placement, and 2) dredging channels to contain booster pumps required for long pumping distances. Scoring for destruction of piping plover habitat, where piping plovers have actually been found in past investigations, is a 0 (zero) if no sites of habitat are destroyed; a –1 if 1 to 10 sites are destroyed; a –2 if 11 to 100 sites are destroyed; and a –3 if more than 100 sites are destroyed. For impacts to benthos (bay bottom), solid phase (SP) bioassay and bioaccumulation data were examined. Since these data are not amenable to areal impact descriptions, a score of –1 was applied if the (see Section 2.4) LPC for SP bioassays was not met, a –2 was applied if the LPC for bioaccumulation was not met, and a –3 was applied if both were not met.

2.8.2.2 Water Column Effects

For water column impacts for constituents for which there are numerical criteria in the WQS, two zones were used: the Zone of Initial Dilution (ZID) and the Mixing Zone (MZ). The ZID and MZ are described in the Texas Surface Water Quality Standards (30 TAC §§307.1-307.10) and the implementation of the TCEQ Standards via Permitting (TNRCC, 1995). For open bays, they are defined as the volume of water within a 50-foot and 200-foot radius of the discharge point, respectively.

The elutriate was used as the measure of water column impact of a particular constituent, after accounting for the concentration of that constituent in the waters of the Laguna Madre. For consistency with §§307.1–307.10, if the acute marine WQSs were not exceeded at the end of the discharge pipe, a score of 0 was assigned. If the acute marine WQSs were exceeded at the end of but not beyond the discharge pipe but were not exceeded inside of the ZID (i.e., allowing for mixing that would occur in the ZID), a score of –1 was assigned. If the acute marine WQSs were exceeded inside but not beyond the ZID, a score of –2 was assigned. If the chronic marine WQSs were exceeded in but not beyond the MZ, a score of –3 was assigned. In actuality, an examination of the data indicated a few stations from the 1980s for which slight exceedance of WQSs would have occurred at the end of the discharge pipe only. However, the instances were few and all recent data indicated no exceedances, so no scoring was based on chemical analyses of the elutriates.

For turbidity, the with-placement scenario was compared with the without-placement scenario for the sediment transport modeling. If TSS, under these circumstances, increased by more than 25 milligrams per liter (mg/L) for at least 3 months, a score of –1 was assigned; more than 50 mg/L for at least 3 months, a score of –2 was assigned; and more than 100 mg/L for at least 3 months, a score of –3 was assigned. This determination was based on potential impacts to seagrasses provided in the results of the Seagrass Modeling (Burd, 2002). Additionally, an examination was made of plots provided in Teeter et al. (2003) that compared the isopleths (lines of equal value) for 20 percent irradiance reaching the seagrasses, with and without open-bay dredged material placement. The differences in areas were estimated and summed by reach, in acres. These acre values were assigned a score the same as the acres of other areal impacts noted above.

For other constituents, bioassay data were examined and the toxicity limitations given in §§307.6(c)(7) were applied to the zones noted above, such that if the toxicity criterion was not violated at the discharge pipe, a score of 0 was assigned. If the toxicity criterion was exceeded only inside the ZID, a score of –1 was assigned; outside the ZID but not outside the MZ, a –2 was assigned; and outside the MZ, a –3 was assigned. Since water column impacts were estimated by several different methods, the individual scores applied by each method were divided by the number of methods used for that particular activity so that the total score for any activity, per reach, for water column impacts did not exceed 3. In actuality, like the elutriate discussion noted above, no scoring occurred with this method since violation of the toxicity criterion was not indicated by any of the data.

In addition to water quality impacts, there were other water column impacts from some alternatives. Creation of open-bay confined and open-bay semiconfined placement areas would displace a volume of water that was available to nekton and plankton. Considering the volume of the placement areas versus the volume of water in the Laguna Madre, this is a small but real impact, but one which is difficult to quantify. Therefore, it was assigned a value of –1.

2.8.2.3 Human Use Effects

Human Use Effects was a complicated receptor category. It was comprised of considerations concerning commerce, recreation, fishing, hunting, tourism, human safety, and land use. Impacts to commerce were reflected in the dredging frequency and duration, since this could affect barge traffic in the GIWW. These two items also affect recreation, fishing, hunting, and tourism since people engaged in these activities often use the GIWW for access to their destinations. The length of pipeline involved in dredged material placement and the duration of dredging affect human safety, as well as recreation, fishing, hunting, and tourism since pipelines running in the GIWW reduce access into and egress from the GIWW. Pipelines running perpendicular to the GIWW and emergent placement areas restrict movement in the Laguna Madre and provide a potential danger to boaters. Upland confined placement areas impact the land use of the landowners, but may provide bird hunting benefits, as may open-bay confined placement. However, impacts to land owners are quantifiable whereas potential benefits to bird hunting is not.

Dredging duration in days for dredging and levee construction was listed under Dredging Activity, since together they equal the total impact to human use for the GIWW, and were scored as follows: differs by less than 100 days = 0, differs by 100 – 500 days = 1, differs by 500 – 1,000 day = 2, and differs by >1,000 days = 3. Pipeline lengths and duration are presented as the number of pipeline-mile-days (pmd) per 50 years. Land use impacts are presented as acres and scored like all other acreages. For pmd, the ICT determined that 0 – 100 pmd received a score of 0; 101 – 2,500 pmd, a score of 1; 2,501 – 10,000 pmd, a score of 2; and >10,000 pmd, a score of 3. There are coastal cabins located on dredged material placement areas in some reaches. These cabins and associated structures are permitted by the GLO. The creation of open-bay confined and open-bay semiconfined placement areas has the potential to destroy some of these cabins, with impacts to the human uses of those facilities. Scoring for destruction of coastal cabins is a 0 if none are destroyed; a –1 if 1 to 10 are destroyed; a –2 if 11 to 100 are destroyed; and a –3 if more than 100 are destroyed. Long-term aesthetic impacts were given a score of 0 for levee heights <20 feet, a score of –1 for levee heights of 21 to 35 feet, a score of –2 for levee heights of 36 to 50 feet, and a score of –3 for levee heights >50 feet. As with other receptors, if more than one method was applied to Human Use Effects, an average was used such that the maximum score by reach, per activity, did not exceed 3.

2.8.3 Activities

After considerable discussion and trying to assign a score to the impacts of maintenance dredging and dredged material placement to the various receptors, the ICT determined that the process of maintenance dredging would have to be broken into various activities before one could logically examine impacts. Therefore, the impact from each alternative on any given receptor was broken into four activities: dredging impacts, impacts from the conveyance of dredged material, impacts from the placement of the dredged material, and post-placement impacts.

Dredging Activity impacts are those that occur during and because of the dredging, *per se*, and are independent of the transport and/or placement of the dredged material. These include the turbidity at the dredging site and impacts to benthos that might be in the maintenance material. Conveyance Activity impacts are those that occur during and because of the transport of the dredged material from the dredge to the placement area. These include impacts to human health and fisheries economics from pipelines across the Laguna Madre, impacts to seagrass and benthos from laying pipelines across the Laguna, impacts to seagrass and benthos from dredging canals to place booster pumps, etc. Placement Activity impacts are those associated solely from the placement of dredged material. These include impacts to terrestrial flora and fauna from the creation of upland placement areas, impacts to seagrass and benthos from creation of open-bay confined or semiconfined placement areas, turbidity from open-bay unconfined placement, etc. Post-placement Activity impacts are those associated with the fact that some placement options have long-term implications for various ecosystems or are outside the footprint of the placement site. For example, open-bay nonconfined and semiconfined placement would allow dredged material to flow outside of the placement area. Upland confined and open-bay confined may reduce the frequency of dredging as well as reducing the turbidity from resuspension of placed material.

2.9 INFORMATION ON PLACEMENT ALTERNATIVES

This section provides additional information used in the generation of the Point Values that went into the Matrix. It includes a discussion of the various basic placement options: i.e., offshore; upland; beach nourishment; open-bay; confined; and semiconfined; and what types of impacts these various options will cause. Like the cost data, some of this information was developed before the Screening Criteria were applied and some was required for application of the criteria. Therefore, data concerning some options, which have been excluded by the Screening Criteria, are included for information purposes only.

2.9.1 Present Practices

2.9.1.1 Reach 1

At present, all maintenance material from Reach 1 is placed in PAs 176–191, which are unconfined, open-bay placement areas, except for PA 176, which is confined.

2.9.1.2 Reach 2

At present, all maintenance material from Reach 2 is placed in PAs 192–202, which are unconfined, open-bay placement areas, except that part of PA 202 is confined.

2.9.1.3 Reach 3

Presently, maintenance material from Reach 3 is placed in PAs 203, 204, 206–210 in the Land Cut. PA 204 is completely leveed, while parts of PAs 203, 206, 207, and 208 are partially leveed. PA 210 has some incomplete levees to direct the flow of dredged material away from the GIWW. Since, under ordinary circumstances, little dredging is required in this reach, there is sufficient capacity in the present placement areas for the 50-year life of the project.

2.9.1.4 Reach 4

At present, all maintenance material from Reach 4 is placed in PAs 211–222, which are unconfined, open-bay placement areas, except that PA 211 has some incomplete levees to direct the flow of dredged material away from the GIWW and part of PA 222 is confined.

2.9.1.5 Reach 5

At present, all maintenance material from Reach 5 is placed in PAs 223–228, which are unconfined, open-bay placement areas, except that PA 226 is confined and PA 225 is semiconfined.

2.9.1.6 Reach 6

At present, all maintenance material from Reach 6 is placed in PAs 229–239, which are unconfined, open-bay placement areas.

2.9.2 Offshore

For all material to go offshore (i.e., ocean placement), three options were examined: oceangoing hopper dredges, pipeline dredges and hopper barges or scows, and pipeline dredges and pipelines. All of these options would remove maintenance material from the Laguna Madre system, so that the future maintenance frequencies were reduced by 14 percent to account for this. This percentage reduction was based on information derived from the Sediment Transport Computer Model, conducted by the Waterways Experiment Station of the USACE (Teeter et al., 2003).

2.9.2.1 Oceangoing Hopper Dredges

Because of their size, these dredges are not able to turn around in the GIWW, without dredging a turnaround basin. A series of dredged turnaround basins in the Laguna Madre was not included as a viable possibility. The dredges would have to enter and exit the GIWW through three possible channels: Corpus Christi (CC), Port Mansfield (PM), and Brazos Island Harbor (BIH). For example, for Reaches 1, 2, 3, and most of 4 (the CC-PM Section), the dredge would enter via the Corpus

Christi Ship Channel, locate the position of last dredging, dredge until full, exit through the Port Mansfield Channel, and deposit the dredged material in a Port Mansfield ODMDS. The dredge would then reverse this procedure, entering at Port Mansfield and depositing the dredged material in a Corpus Christi ODMDS. It would then go back through the GIWW to the Port Mansfield Channel ODMDS, etc. For the rest of Reach 4, and for all of Reaches 5 and 6 (the PM–PI Section), this scenario would be repeated using BIH and Port Mansfield ODMDSs. Three full-time dredges and one at 44 percent of the time would be required for Reach 1. Five full-time dredges would be needed for Reach 2 and one at 50 percent; three dredges in Reach 3 at 100 percent and one at 52 percent. Four dredges would be needed in the northern portion of Reach 4 at 100 percent and one at 42 percent; one dredge in the southern portion of Reach 4 at 63 percent; one dredge in Reach 5 at 39 percent; and two dredges in Reach 6 at 100 percent and one at 23 percent. Dredging of the various reaches could not be conducted independently but would have to be carefully coordinated. Looking at the CC–PM section as one large reach for ocean placement purposes, there would be an average of 16.9 dredges, going up and down the GIWW, 24 hours per day. There would be an average of 3.2 dredges in the PM–PI Section. These two combined would yield a minimum of 20.1 dredges/day (13,117 trips/year) in the GIWW through the Laguna Madre, assuming that needs for maintenance dredging in the various reaches could be accomplished using the fewest possible dredges and that this number of dredges could be located and made available. This represents an increase of 880 percent over the 1,681 self-propelled commercial vessel trips through this portion of the GIWW (both directions) during 1997 (USACE Navigation Data Center, Waterborne Commerce Statistical Center, 2000). An 880 percent increase in vessel traffic would greatly increase both bank erosion and the possibility of a spill by collision in the Laguna. New ocean placement sites, or expansion of present sites, would be required, necessitating the preparation of site designation EISs.

Assumptions made in the impact analysis are 1) the use of a 1,300-cy dredge (roughly 130 cy of dredged material would be transported per round trip since maintenance material is typically 20 percent solids; the dredge is half-loaded; and no overflow to increase the solids content is allowed, because that would cause the release of suspended solids; a dredge larger than this would not be able to work the GIWW), 2) 8.1-mile per hour (mph) speed loaded and 10.8-mph speed unloaded (Lockhart, pers. comm.), 3) 112.5-mile round trip for CC–PM section and 53.2-mile round trip for the PM–PI section, 4) 1 hour of dredging to fill hoppers, 5) a 20-hour average workday, and 6) that dredges of this size could pass under the causeways at each end. The last assumption is valid, but there is only a few feet of clearance for the JFK Causeway and then only in the very center of the causeway.

Reach 1 maintenance would require 5,519 trips and 117.0 dredging-months per dredging cycle by oceangoing hopper dredges, which would travel a total of 620,859 miles. With a 34.0-month dredging frequency, dredging could not be completed with only one dredge.

Reach 2 maintenance would require 8,402 trips and 178.1 dredging-months per dredging cycle by oceangoing hopper dredges, which would travel a total of 945,236 miles. With a 32.4-month dredging frequency, dredging could not be completed with only one dredge.

Reach 3 maintenance would require 4,878 trips and 103.4 dredging-months per dredging cycle by oceangoing hopper dredges, which would travel a total of 548,820 miles. With a 29.4-month dredging frequency, dredging could not be completed with only one dredge.

Reach 4 maintenance would require 3,852 trips and 83.8 dredging-months per dredging cycle in the northern part and 1,094 trips and 11.9 dredging-months per dredging cycle in the southern part by oceangoing hopper dredges, which would travel a total of 444,608 and 58,179 miles, respectively. With a 19.0-month dredging frequency, dredging in the northern part could not be completed with only one dredge.

Reach 5 maintenance would require 1,204 trips and 13.1 dredging-months per dredging cycle by one oceangoing hopper dredge, which would travel a total of 64,051 miles. Reach 5 is the only reach in which dredging could be completed by only one dredge.

Reach 6 maintenance would require 4,738 trips and 51.6 dredging-months per dredging cycle by oceangoing hopper dredges, which would travel a total of 252,043 miles. With a 23.2-month dredging frequency, dredging could not be completed with only one dredge.

In addition to the above, hopper dredges are not allowed to be used in some areas because of the potential for greater impacts to sea turtles by these dredges.

2.9.2.2 Cutterhead Suction Dredges

These dredges are the same cutterhead pipeline dredges that are used for present practice in the Laguna Madre, except that, instead of pumping the short distance into the designated placement areas, they would pump long distances to the ocean or would pump into hopper barges or scows.

Cutterhead Suction Dredges and Scows

When this analysis was being conducted, there were two 4,000 cy scows and two 2,000 cy scows available for use on the Texas Coast (G&B, 1997). To be used in the GIWW, these barges could only be half-loaded, so the amount of maintenance material that can be moved by tugs and scows is 1,200 cy per trip to the ODMDSs, assuming that the material coming from the suction head into the scows is 20 percent solids and no overflow to increase the solids content is allowed, because that would cause the release of suspended solids. To arrive at rough costs for this placement alternative, it was assumed that while the scows were being filled, the tugs which brought the scows from the ODMDSs would untie and go to the other end of the scow, so that the one-way trip scenario discussed above for hopper barges would not be true for pipeline dredges and scows. Even so, the average round-trip distances to the ODMDSs are not short, ranging from 30 miles in Reach 4 to 111 miles for Reach 2. Therefore, the amount of material that can be removed from the GIWW each day is dependent on the amount that can be transported in the scows, not the amount that can be dredged (approximately 1,800 cy/hour = 43,200 cy/day). Therefore, the amount of maintenance material that can be removed each day ranges from 865 cy for Reach 2 to 3,200 cy for Reach 4, leading to dredging times per dredging cycle ranging from 44 days (0.1 years) for the southern part of Reach 4 to 1,263 days (3.5 years) for Reach 2. The per-reach dredging time only exceeds the per-reach dredging cycle for Reach 2. For all reaches, three dredges and associated scows would be required 100 percent of the time and a fourth would be needed roughly 23 percent of the time. Thus, for this alternative, at all times there would be three dredges and 12 scows and tugs in the GIWW, 24 hours per day. During 23 percent of each year, there would be four dredges and 16 scows and tugs in the GIWW, 24 hours per day. The following table (Table 2-6) presents the following for each reach (Reach 4 is divided into North and South of Port Mansfield): the time required to dredge the reach (Dredging Time); the frequency with which the reach has been historically dredged, reduced by 14 percent for removal of sediment from the Laguna Madre system (Dredging Cycle); the amount of time in each dredging cycle when dredging would actually be occurring with one dredge and four scows (Dredging Time/Dredging Cycle); the number of round trips by scow-tug combination per dredging cycle (Number of Trips); and the number of miles covered by the scows and tugs per cycle (Number of Miles).

TABLE 2-6

PARAMETERS FOR CUTTERHEAD
SUCTION DREDGES AND SCOWS

Reach	Dredging Time	Dredging Cycle	Dredging Time/ Dredging Cycle	Number of Trips	Number of Miles
1	1.6 years	2.8 years	0.55	2,391	181,751
2	3.5 years	2.7 years	1.28	3,641	404,141
3	1.6 years	2.5 years	0.63	2,114	181,802
4 North	0.4 years	1.6 years	0.28	1,713	51,377
4 South	0.1 years	1.6 years	0.08	474	14,217
5	0.2 years	2.8 years	0.08	522	25,564
6	0.6 years	1.9 years	0.33	2,053	73,907
Total			3.23	12,908	932,759

This alternative would lead to a minimum of 12.9 scow/tug trips/day (5,684/year) in the GIWW through the Laguna Madre, assuming that needs for maintenance dredging in the various reaches could be accomplished using the fewest possible barges and that this number of barges could be located and made available. This represents an increase of 438 percent over the 1,681 self-propelled commercial vessel trips through this portion of the GIWW (both directions) during 1997 (USACE Navigation Data Center, Waterborne Commerce Statistical Center, 2000). A 438 percent increase in vessel traffic would greatly increase both bank erosion and the possibility of a spill by collision in the Laguna Madre. New ocean placement sites, or expansion of present sites, would be needed, requiring the preparation of site designation EISs.

Cutterhead Suction Dredges with Pipeline Discharge

In most of Reaches 1 and 4 and all of Reaches 2 and 3, the pipelines to the ocean would have to cross the PINS, which violates the Federal Regulations Screening Criterion. An option would be to run the pipeline along the GIWW, north or south of the PINS, and then go offshore. In the other portions of Reaches 1 and 4 and the other reaches, channels across the Laguna Madre would have to be dredged each dredging cycle for the boosters that would be required to push the material all the way to the ODMDSs, which would require the preparation of a number of site designations EISs. Additionally, boosters would be needed because of the long pumping distances and there is a 10 percent loss of volume pumped for each booster used (USACE data). With a booster needed every 2 miles (USACE data), any reach over 22 miles (116,160 feet) would require so many boosters that there would be no discharge at the end of the pipe. Therefore, this placement alternative is not feasible. This applies to all reaches where direct routes would cross the PINS, including the northern portion of Reach 4, since a pipeline run along the GIWW north or south of the PINS and then offshore would average longer than 22 miles.

Acres of impact are provided below (Table 2-7), based on the approximate percentage of seagrass to open-bay bottom in the reach. Since precise routes were not available, precise determinations of seagrass to open-bay bottom ratios were not possible. The area for the channels for booster pumps is a subset of the Laguna Madre area needed for pipeline placement since the pipelines would be connected to the boosters and, therefore, run in the channels. However, while the pipeline placement would be a recurrent but temporary impact, the dredging of channels for booster pump placement would be a permanent removal of habitat. Dredging and construction days for Human Use Impacts are also presented.

TABLE 2-7

SUMMARY OF MATRIX IMPACTS FOR CUTTERHEAD SUCTION DREDGES WITH OFFSHORE PIPELINE DISCHARGE

Reach	Seagrass (ac)	Bay Bottom	Emergent Habitat	Terrestrial Habitat	Dredging and Construction Days
1	61	75	0	59	2,591
5	82	0	72	15	721
6	124	10	7	24	1,942

2.9.3 Upland

2.9.3.1 Confined Upland

This option presumes placement in new, leveed sites on the mainland (Upland Confined Placement Areas [UCPAs]), except for Reach 3. Sites would have to be selected and the State of Texas, as local sponsor, would be responsible for land acquisition. Although UCPAs were identified on a map distributed to the ICT, these sites are not necessarily available and were selected only to calculate typical distances for cost estimates. However, even though upland placement of dredged material may not be immediately feasible due to the lack of easements, point values were assigned.

The sizes of the UCPAs, for initial storage, were calculated by the formulae used in the Automated Dredging and Disposal Alternatives Management System (ADDAMs) models developed at the Waterways Experiment Station of the Corps of Engineers (USACE, 1987. EM 1110-2-50270). Assumptions used to calculate the areas are: 1) levee height sufficient to allow a freeboard of 2 feet and a ponding depth of 2 feet, 2) in situ water content of 98.3 percent, 3) 24-inch pipeline with a discharge rate of 15 fps, 4) average operating day of 18 hours at 1,800 cy per hour (reduced for pipelines and boosters, where appropriate), and 5) TSS in the discharge to be ≤300 mg/L (allowed by the 2-foot ponding depth). The levee height was adjusted in the formulae to 30 feet, since that is approximately the maximum levee height attainable with GIWW material (Hrametz, 2000). The grain size distribution from the USACE historical database and from LWA (1998), the salinity data from LWA (1998a), and the measurements conducted for Morton et al. (1998) on GIWW maintenance material in the Laguna Madre were used in the calculations. Sites were chosen to allow for reasonable pipeline distances. Impact areas for pipelines assume that a 100-foot swath would be affected during the emplacement and removal of the pipelines and that channels would have to be dredged for booster pumps. The initial storage requirement is the maximum required by the ADDAMS formulae for all material to be dredged during 50 years with 30-foot levees. No allowance was made for compaction between dredging cycles, so placement area sizes are worst case. Some compaction will occur between dredging cycles and, innovative techniques could increase the amount of compaction, thus reducing the required levee heights or placement area sizes. However, any such determinations are unnecessary for the alternatives analysis since the same formulae were used for all reaches. This scenario, like ocean placement, would remove the maintenance material from the system, so that the future maintenance frequencies were reduced by 14 percent.

As noted above, all reaches were broken into segments to prevent the distance from the dredge to the UCPA from exceeding 7 miles, which does not show new sites in Reach 3, since existing upland areas, including some leveed placement areas already exist. The table below (Table 2-8) presents a summary of the calculated results.

TABLE 2-8

PLACEMENT AREA DESCRIPTORS BY REACH

	Reach 1			Reach 2		Reach 3			
Segment:	1	2	3	4	5	6	7	8	9
External Area Initial (acres)	76	178	343	270	601	73	300	141	72
Levee Heights Long-Term (feet)	30	30	30	30	30	30	30	30	30

TABLE 2-8 (Concluded)

	Reach 4				Reach 5		Reach 6		
Segment:	10	11	12	13	14	15	16	17	18
External Area Initial (acres)	290	244	298	161	104	52	251	444	56
Levee Heights Long-Term (feet)	30	30	30	30	30	30	30	30	30

The external acreages above for Reach 3 total 586 acres, while the total amount of emergent acreage is roughly 2,576 acres. Therefore, there should be no impacts on piping plover habitat or coastal cabins in Reach 3.

Additionally, the following table (Table 2-9) presents the acres of various receptors from the pipelines that would need to be placed across the Laguna and upland areas to the placement areas. The area for the channels for booster pumps is a subset of the Laguna Madre area needed for pipeline placement since the pipelines would be connected to the boosters and, therefore, run in the channels. However, while the pipeline placement would be a recurrent but temporary impact, the dredging of channels for booster pump placement would be a permanent removal of habitat. Acres of impact are provided below, based on the approximate percentage of seagrass to open-bay bottom in the reach. Since precise routes were not available, precise determinations of seagrass to open-bay bottom ratios were not possible.

TABLE 2-9

ACRES OF MATRIX IMPACTS FOR PIPELINE PLACEMENT BY REACH

Reach	Seagrass (ac)	Bay Bottom (ac)	Emergent Habitat (ac)	Terrestrial Habitat* (ac)
1	23	28	40	12
2	8	18	10	1
3	0	0	0	0
4	40	59	16	9
5	29	10	30	0
6	38	42	4	28

* While not quantifiable, there would be losses of Terrestrial Habitat from road construction associated with placement area construction.

ac = acres.

The following table (Table 2-10) presents the dredging/construction days and pmd, per 50 years, for conveyance of dredged material by reach and the acres of land use involved in placement.

TABLE 2-10

SUMMARY OF HUMAN USE MATRIX IMPACTS FOR UPLAND CONFINED PLACEMENT BY REACH

Category	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
Days	1,317	1,613	870	1,639	258	428
pmd	9,217	11,288	870	11,473	1,808	2,998
Land use	609	872	586	1,000	156	779

There are 31 coastal cabins on existing placement areas in Reach 3, none of which would be affected by confined upland placement in Reach 3.

2.9.3.2 Thin Layer

This placement option allows dredged material to be placed on an upland area, as a beneficial use. In general, a small levee or dike is used parallel to the channel being dredged, and possibly one or two others perpendicular to the channel, to keep the dredged material from flowing back into the channel. The placement is designed so that a sediment layer roughly 6–12 inches thick is produced. A layer such as this allows nutrients in the dredged material to be transferred to the soils but allows the salt content to be reduced by rain such that relatively rapid revegetation can occur. The results of an experimental thin-layer placement have been described in TAMU (1999).

Since the dredged material would be pumped to the Thin Layer Upland Placement Areas, just as it would for the Upland Confined Placement alternative, the same segments noted in Section 2.9.2.1 were used for Thin Layer. This option is not feasible for Reach 3 because there is insufficient upland area that would benefit from this type of treatment in this reach. Additionally, because of the size of the area impacted, this alternative would only be considered with the consent of a landowner. Based on an average thickness of 6 inches of material, after drying, the areal extent of the placement areas by reach and segment; and the acres of seagrass, bay bottom, and terrestrial habitat that would be impacted by the pipelines conveying the material to the placement areas, by reach, are presented below (Table 2-11). Acres of impact are based on the percentage of seagrass to open-bay bottom in the reach. Since precise routes were not available, precise determinations of seagrass to open-bay bottom ratios were not possible. The area for the channels for booster pumps is a subset of the Laguna Madre area needed for pipeline placement since the pipelines would be connected to the boosters and, therefore, run in the channels. However, while the pipeline placement would be a recurrent but temporary impact, the dredging of channels for booster pump placement would be a permanent removal of habitat. The impacts from the pipeline corridors are the same as those for upland confined, but the placement area size is not.

TABLE 2-11

SUMMARY OF MATRIX IMPACTS FOR
THIN LAYER PLACEMENT BY SEGMENT

Reach	Segment	PA (ac)	Seagrass (ac)	Bay Bottom (ac)	Emergent Bay (ac)	Terrestrial Habitat* (ac)
1	1	1,758				
1	2	4,563	23	28	40	12
1	3	9,417				
2	4	7,904				
2	5	17,261	8	18	10	1
3	6	Not feasible				
3	7	Not feasible				
3	8	Not feasible				
3	9	Not feasible				
4	10	7,837				
4	11	6,283				
4	12	7,826	40	59	16	9
4	13	3,861				
5	14	2,471				
5	15	973	29	10	30	0
6	16	6,453				
6	17	12,230	38	42	4	28
6	18	1,164				

* While not quantifiable, there would be losses of Terrestrial Habitat from road construction associated with placement area construction.

ac = acres

The following table (Table 2-12) presents the dredging/construction days and pmd, per 50 years, for conveyance of dredged material by reach and the acres of land use involved in placement.

TABLE 2-12

SUMMARY OF HUMAN USE MATRIX IMPACTS FOR
THIN LAYER PLACEMENT BY REACH

Category	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
Days	1,317	1,613	N/A	1,639	238	428
pmd	9,217	11,288	N/A	11,473	1,608	2,998
Land use	15,674	25,097	N/A	25,816	3,444	19,874

2.9.4 Beach and Washover Nourishment

Beach Nourishment would be by transportation of dredged material from the GIWW to the beaches of South Padre Island to replenish sand, which is being eroded by natural processes. For washover nourishment, the pipelines would go to selected washover areas. For nourishment to occur, pipelines would have to be laid from the GIWW across the bays and islands to the beach or washover. These pipelines would normally be floated on the bay surface, causing problems for recreational boaters, especially at night. To ease this problem for recreational boaters, a submerged section could probably be included every few thousand feet for recreational boaters to pass easily over the submerged pipeline at low tide, provided water depths are sufficient.

A formal site designation from the EPA would not be required for beach or washover nourishment, but all information necessary to demonstrate lack of impact would be required. This basically includes putting the results of past testing conducted on the dredged material into a format sufficient to satisfy the Section 404(b)(1) Guidelines.

The primary difficulty with beach and washover nourishment is that only Reach 3 material, which has the most sand of any reach at 75 percent sand, on average, is marginally suitable for nourishment due to grain size. The material from the other reaches ranges from 51 to 9 percent sand with a high silt fraction. Therefore, only the material from Reach 3 can be used feasibly for nourishment. Additionally, for all of Reaches 2 and 3, and parts of Reaches 1 and 4, the pipeline would have to cross the PINS, which violates the Federal Regulations Screening Criterion. Reach 3 also does not have sufficient washover areas to accommodate all of the maintenance material from the GIWW, even if the grain size were coarser to match existing sediments.

2.9.5 Open Bay

Open-bay placement is of three varieties: unconfined, which would be a continuation of existing practice for all Reaches except Reach 3, semiconfined, and confined. For Reach 3, new sites would be required in the popular fishing spot known as The Hole for open-bay placement to be used. Because of the concerns for which this FEIS is being prepared, transporting material by pipeline out of the Land Cut for placement in the Laguna Madre would not be logical and was not recommended by the ICT.

2.9.5.1 Unconfined

As noted above, open-bay unconfined placement would be the continuation of the present practice in all reaches, except for Reach 3 in the Land Cut. Material is dredged by a cutterhead pipeline dredge and pumped via pipeline into the existing open-water placement areas and allowed to flow by gravity and currents onto the Laguna bottom. Mounding occurs next to the discharge pipe and the dredged material feathers out from there. Potential impacts would include burial of benthic organisms and seagrasses and increased turbidity. Seagrasses can endure burial of roughly 3 inches (Dunton et al., 2003). Since 6 inches of accumulation was assumed for the calculation of the Thin Layer Placement option and since not all material stays on site with open-bay unconfined placement, the same acreages as Thin Layer were used to calculate the area of impact for open-bay unconfined placement. These are

Reach 1: 948 acres (853 seagrass, 95 bay bottom); Reach 2: 1,517 acres (737 seagrass, 780 bay bottom); Reach 3: 820 acres (533 seagrass, 287 emergent land); Reach 4: 957 acres (362 seagrass, 595 bay bottom); Reach 5: 151 acres (122 seagrass, 29 bay bottom); and Reach 6: 746 acres (298 seagrass, 448 bay bottom). These acreages were used in the impacts to seagrass, bay bottom, and emergent habitat. For Reach 3, Open-Bay Unconfined placement would involve piping material to The Hole, which would impact seagrasses and sand/algal flats.

The following table (Table 2-13) presents the acreage between the isopleths for 20 percent irradiance reaching the seagrasses, with and without open-bay dredged material placement, by month for the first 3 months after dredging and unconfined open-bay placement from the model of 'worst case' scenario. The 3-month average was used for scoring.

TABLE 2-13

20% IRRADIANCE REDUCTION FOR UNCONFINED OPEN-BAY PLACEMENT BY REACH

Month	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
April	0	227	NA	362	17	314
May	0	14	NA	19	0	114
June	0	9	NA	11	14	101
Average	0	80	0*	131	10	176

* This number is assumed based on higher sand content since no open-bay placement was included in the model for Reach 3.

The average TSS was not higher than 25 mg/L for any 3 months after dredged material placement in any reach, according to the modeling conducted for the use of ICT by the USACE Waterways Experiment Station (WES) (Teeter, 2000). Average TSS values above 100 mg/L only occurred in the 119 hours during placement activities. A TSS average above 50 mg/L occurred in Reaches 2 and 4 during the month of simulated placement activities (April 1995) but not after April.

Open-bay unconfined placement has not historically impacted either coastal cabins or piping plover habitat (Drake et al., 1999). The following table (Table 2-14) presents the dredging/construction days and pmd, per 50 years, for conveyance of dredged material by reach and the acres of land use involved in placement.

TABLE 2-14

SUMMARY OF HUMAN USE MATRIX IMPACTS FOR UNCONFINED OPEN-BAY PLACEMENT BY REACH

Category	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
Days	659	862	1,526	861	78	213
pmd	659	862	21,360	861	78	213

2.9.5.2 Open-Bay Confined

This scenario presumes that all material will be placed in leveed areas, as with upland placement, but the leveed areas would be along the GIWW. This is present practice only for Reach 3. Fifteen feet was considered to be the practical upper levee-height limit for confined placement areas in the open bay, since open-bay levees would be constructed with geotextile tubes (a pyramidal set of six geotextile tubes would be used to achieve a height of 15 feet). Since upland placement sites were designed with constructed earthen levees, up to 33 feet in height, the areas needed for open-bay confined placement are considerably larger than for upland confined placement. The segments used for UCPAs are not used here since the limitation on pumping distance does not apply. Therefore, the area required for each existing placement area has been calculated and compared with the size of the emergent portion of each placement area. This scenario, like ocean placement and upland confined placement, would remove the maintenance material from the system, so that the future maintenance frequencies were reduced by 14 percent (a reduction in the frequency of dredging). Ratios of seagrass to open-bay bottom differ from those used for pipeline and booster channels in the previous sections and were taken from seagrass maps of the placement areas in each reach. The construction of open-bay confined placement areas would also displace a water volume that had been available to nekton and plankton.

Reach 1. This reach contains PAs 175–191. The acreage of each placement area, the emergent land present on each placement area, the maximum acreage required for open-bay confined placement for each placement area, and the amount of additional area that would need to be created, above the emergent land available, is listed below for this reach (Table 2-15). Overall, confined placement would require roughly 1.8 times the placement area of Upland Placement, or approximately 1,003 acres, if it is assumed that the levees are built to a total height of 15 feet, which would allow roughly 11 feet of maintenance material after consolidation. No bay or upland impacts would occur, except those associated with the construction of the additional levees and enclosed placement areas. Habitat similar to that on existing leveed areas in Reach 3 would be created from existing Laguna Madre bottom and emergent areas. These areas would then be periodically covered with maintenance material and impacts similar to those from Upland Confined placement would occur in the placement areas. As noted below, no bay bottom habitat would be needed for PAs 175–184, but roughly 787 acres of Laguna bottom would be covered for PAs 185–191. Of this total, it is estimated that 709 acres would be seagrass and 78 acres would be unvegetated bay bottom. There are 42 coastal cabins on existing placement areas in Reach 1. However, due to the large amount of emergent area available, it appears that only the four of them on PAs 186, 187, and 189, where additional area is required, would be affected by construction of open-bay confined placement areas. Additionally, piping plovers were found on six placement areas in Reach 1 (EH&A, 1993). However, due to the amount of available emergent area versus the much smaller amount of area needed for confined placement on the placement areas with piping plover sites, it would appear that none of these sites will be impacted. There would be 1,919 dredging/construction days and 14,390 pipeline-mile days for Reach 1 over the 50-year period.

TABLE 2-15

ACREAGE BY PLACEMENT AREA FOR CONFINED
OPEN-BAY PLACEMENT FOR REACH 1

PA	Total Area	Emergent Area	Area Required for Confined Placement	Additional Area Required
175	29.1	28.4	0.0*	0.0
176**	133.8	113.4	10.2	0.0
177	35.8	27.0	5.9	0.0
178	125.3	78.6	15.3	0.0
179	40.1	23.9	5.1	0.0
180	125.6	76.1	43.2	0.0
181	96.6	58.9	33.0	0.0
182	58.5	36.5	16.1	0.0
183	152.1	59.3	22.7	0.0
184	98.7	43.9	28.2	0.0
185	105.4	33.6	42.9	9.3
186	117.4	2.4	91.2	88.8
187	137.8	0.0	174.2	174.2
188	165.8	0.0	198.1	198.1
189	124.7	0.0	161.5	161.5
190	69.9	0.0	94.3	94.3
191	57.3	0.0	61.1	61.1
Total	1,673.9	582.0	1,003.0	787.3

* Never used.

** PA 176 is partially confined, but will be fully confined during the next dredging cycle it is used.

Reach 2. This reach contains PAs 192–202. For this reach, the same information, as for Reach 1, is provided below (Table 2-16). Overall, confined placement would require roughly 1.9 times the placement area of Upland Placement, or approximately 1,525 acres, if it is assumed that the levees are built to a total height of 15 feet. No bay or upland impacts would occur, except those associated with the construction of the additional levees and emergent areas. Habitat similar to that on existing leveed areas in Reach 3 would be created from existing Laguna Madre bottom areas and these areas would be periodically covered with maintenance material and impacts similar to those from Upland Confined placement would occur in the placement areas. A total of 1,214 acres of Laguna bottom would be covered to create the confined placement areas. Of this, it is estimated that 590 acres would be seagrass and 624 acres would be unvegetated bay bottom. There are 33 coastal cabins on existing placement areas in Reach 2, all of which would be demolished with the construction of open-bay confined placement areas, since additional area is required on all placement areas. Piping plovers were found on two placement areas in Reach 2 (EH&A, 1993), and it would appear that all of that habitat would similarly be covered by creation of the open-bay confined placement areas. There would be 2,284 dredging/ construction days and 18,504 pipeline-mile days for Reach 2 over the 50-year period.

TABLE 2-16

ACREAGE BY PLACEMENT AREA FOR CONFINED OPEN-BAY PLACEMENT FOR REACH 2

PA	Total Area	Emergent Area	Area Required for Confined Placement	Additional Area Required
192	90.6	0.0	53.2	53.2
193	90.6	38.0	54.6	16.6
194	121.5	24.6	74.9	50.3
195	103.0	0.3	68.2	67.9
196	103.0	41.2	50.3	9.1
197	304.4	80.4	341.8	261.4
198	146.2	0.0	168.5	168.5
199	124.9	0.0	170.7	170.7
200	196.2	5.1	169.6	164.5
201	173.7	0.0	183.8	183.8
202	195.6	121.1	189.4	68.3
Total	1,649.7	310.7	1,525.0	1,214.3

Reach 3. This reach contains PAs 203–210, all in the Land Cut (Table 2-17). PA 205 is not used for the GIWW. PA 204 is completely leveed, while parts of PAs 202, 203, 206, 207, and 208 are partially leveed. PA 210 has some incomplete levees to direct the flow of dredged material away from the GIWW. Overall, confined placement would require roughly 1.5 times the placement area of Upland Placement, or approximately 903 acres, if it is assumed that the levees are built only to a total height of 15 feet. Substantial bay impacts would occur since, to achieve open-bay confined placement in Reach 3, confined areas would have to be created in The Hole, an open-water fishing area east of the northern portion of the Land Cut. Habitat similar to that on existing leveed areas would be created from Laguna Madre bay bottom and seagrass habitat and these areas would be periodically covered with maintenance material and impacts similar to those from Upland Confined placement would occur in the placement areas. The Hole is essentially all seagrass or algal/sand flats so that roughly 587 acres of seagrass and 316 acres of algal/sand flats would be buried. There are 38 coastal cabins on existing placement areas in Reach 3, but none would be impacted by construction of open-bay confined placement areas. No piping plovers were found on PAs in Reach 3 (EH&A, 1993, 1997b), but impacts to 316 acres of algal/sand flats would likely impact piping plovers. Channels would have to be dredged into The Hole to provide access for equipment for levee construction. There would be 2,205 dredging/construction days and 30,876 pipeline-mile days for Reach 3 over the 50-year period.

TABLE 2-17

ACREAGE BY PLACEMENT AREA FOR CONFINED OPEN-BAY PLACEMENT FOR REACH 3

PA	Total Area	Emergent Area	Area Required for Confined Placement	Additional Area Required
203	324.5	311.3	66.9	66.9 *
204	167.7	167.7	33.3	33.3
206	380.4	380.4	120.8	120.8
207	322.2	322.2	177.7	177.7
208	769.0	767.0	384.8	384.8
209	193.4	193.4	44.9	44.9
210	242.8	240.7	74.3	74.3
Total	2,400.0	2,382.7	902.7	902.7

* Emergent areas of existing PAs is not applicable for this reach since all PAs would be moved to The Hole.

Reach 4. This reach contains PAs 211–222. The same information, as for Reach 1, is provided below (Table 2-18). PA 211 has some incomplete levees to direct the flow of dredged material away from the GIWW. Overall, confined placement would require roughly 1.8 times the placement area of Upland Placement, or approximately 1,675 acres, if it is assumed that the levees are built to a total height of 15 feet, with 11 feet of maintenance material after consolidation. No bay or upland impacts would occur except those associated with the construction of the additional levees and emergent areas. Habitat similar to that on existing leveed areas in Reach 3 would be created from existing Laguna Madre bottom areas and these areas would be periodically covered with maintenance material and impacts similar to those from Upland Confined placement would occur in the placement areas. A total of 1,514 acres of Laguna bottom would be covered to create the confined placement areas. Of this, it is estimated that 573 acres would be seagrass and 941 acres would be unvegetated bay bottom. There are 6 coastal cabins on existing placement areas in Reach 4, all of which would be demolished with the construction of open-bay confined placement areas. No piping plovers were found on PAs in Reach 4 (EH&A, 1997b). There would be 2,971 dredging/construction days and 17,828 pipeline-mile days for Reach 4 over the 50-year period.

Reach 5. This reach contains PAs 223–228. The same information, as for Reach 1, is provided below (Table 2-19). Overall, confined placement would require roughly 1.5 times the placement area of Upland Placement, or approximately 223 acres, if it is assumed that the levees are built to a total height of 15 feet. No bay or upland impacts would occur except those associated with the construction of the additional levees and emergent areas. Habitat similar to that on existing leveed areas in Reach 3 would be created from existing Laguna Madre bottom areas and these areas would be periodically covered with maintenance material and impacts similar to those from Upland Confined placement would

TABLE 2-18

ACREAGE BY PLACEMENT AREA FOR CONFINED OPEN-BAY PLACEMENT FOR REACH 4

PA	Total Area	Emergent Area	Area Required for Confined Placement	Additional Area Required
211	140.8	45.4	126.7	81.3
212	192.1	0.0	189.4	189.4
213	191.7	0.0	108.1	108.1
214	191.4	0.0	145.6	145.6
215	194.1	0.0	163.4	163.4
216	194.7	0.0	70.1	70.1
217	193.3	0.0	107.8	107.8
218	194.3	0.0	193.5	193.5
219	119.8	0.0	86.9	86.9
220	216.1	2.0	119.2	119.2
221	387.2	63.3	229.1	165.8
222*	259.4	52.6	135.3	82.7
Total	2,474.9	161.3	1,674.8	1,513.5

* Parts of PA 222 are completely leveed.

TABLE 2-19

ACREAGE BY PLACEMENT AREA FOR CONFINED OPEN-BAY PLACEMENT FOR REACH 5

PA	Total Area	Emergent Area	Area Required for Confined Placement	Additional Area Required
223	158.8	137.4	38.4	0.0
224	175.4	172.3	14.2	0.0
225	84.3	77.6	7.8	0.0
226*	257.6	247.6	79.2	0.0
227	65.4	43.0	35.6	0.0
228	294.4	115.1	47.9	0.0
Total	1,035.9	793.0	223.0	0.0

* PA 225 is semiconfined and PA 226 is leveed.

occur in the placement areas. No acres of Laguna bottom would be covered to create the confined placement areas. There are 14 coastal cabins on existing placement areas in Reach 5. However, due to the large amount of emergent area available, it appears that none of them would be affected by construction of open-bay confined placement areas. No piping plovers were found on PAs in Reach 5 (EH&A, 1997b). There would be 339 dredging/construction days and 2,035 pipeline-mile days for Reach 5 over the 50-year period.

Reach 6. This reach contains PAs 229–239. The same information, as for Reach 1, is provided below (Table 2-20). Overall, confined placement would require roughly 1.7 times the placement area of Upland Placement, or approximately 1,239 acres, if it is assumed that the levees are built to a total height of 15 feet. No bay or upland impacts would occur except those associated with the construction of the additional levees and emergent areas. Habitat similar to that on existing leveed areas in Reach 3 would be created from existing Laguna Madre bottom areas and these areas would be periodically covered with maintenance material and impacts similar to those from Upland Confined placement would occur in the placement areas. Except for PAs 233 and 234, not much unvegetated bay bottom would be impacted to create the confined, open-bay placement areas, but a total of 1,153 acres of Laguna bottom would be covered if PAs 233 and 234 are included. The USACE attempted to create open-bay, confined placement areas in 1994, at PA 233 and 234, but the strong currents in the area destroyed both the submerged and emergent levees in a relatively short time frame (Morton, 1998). Therefore, as past experience has shown, even if it were found desirable, creating open-bay, confined placement areas at 233 and 234 could be a difficult task. Of the total acres, it is estimated that 461 would be seagrass and 692 would be unvegetated bay bottom. There are 11 coastal cabins on existing placement areas in Reach 6. However, due to the large amount of emergent area available, it appears that none of them would be affected by construction of open-bay confined placement areas. No piping plovers were found on PAs in Reach 6 (EH&A, 1997b). There would be 686 dredging/construction days and 4,799 pipeline-mile days for Reach 6 over the 50-year period.

TABLE 2-20

ACREAGE BY PLACEMENT AREA FOR CONFINED OPEN-BAY PLACEMENT FOR REACH 6

PA	Total Area	Emergent Area	Area Required for Confined Placement	Additional Area Required
229	129.2	50.4	7.9	0.0
230	82.5	46.5	4.4	0.0
231	127.8	67.0	6.7	0.0
232	127.4	52.5	53.4	0.9
233	210.0	14.7	691.8	677.1
234	121.6	0.0	421.6	421.6
235	121.6	0.0	17.3	17.3
236	129.1	0.0	0.1	0.1
239	49.38	0.0	36.3	36.3
Total	1,098.6	231.1	1,239.4	1,153.3

2.9.5.3 Open-Bay Semiconfined

This alternative would allow runoff from existing confined placement areas, or new semiconfined placement areas on emergent land near the GIWW, onto the flats or open water behind the placement areas. In open-bay areas, levees would have to be constructed on the GIWW side of the placement areas, with wing levees extending for some distance perpendicular to and away from the GIWW, with no back levees. This levee system would partially contain the material and thus, theoretically, create emergent areas. Over time, more Laguna bottom would likely be covered than with confined placement.

Placement would require placing geotextile tubes at the existing open-water placement areas, similar to Confined Open-Bay Placement, except that there would be no back levees. While the decrease in deep-water habitat would be small compared with the overall size of the Laguna, the increase in habitat useful to the shorebird guild is also small considering the vast amount of such habitat in the Laguna. However, the loss of seagrasses by this option and confined placement would probably be the most serious consequences of these two options. This scenario should remove some of the maintenance material from the system, so that the future maintenance frequencies were reduced by 7 percent. Impacts on coastal cabins would be the same as for open-bay confined placement. The construction of open-bay semiconfined placement areas would also displace a water volume that had been available to nekton and plankton.

The areas needed for open-bay semiconfined placement, by reach and placement area are as follows:

Reach 1. This reach contains PAs 175–191. The acreage of each placement area, the emergent land present on each placement area, the maximum acreage required for open-bay semiconfined placement for each placement area, and the amount of additional area that would need to be created, above the emergent land available, is listed below (Table 2-21). Overall, semiconfined placement would require approximately 1,082 acres, if it is assumed that the three levees are built to a total height of 15 feet. Bay impacts would occur from the construction of the additional levees and from runoff from the placement areas. As noted below, no unvegetated bay bottom habitat would be needed for levee creation on PAs 175–184, but a minimum of 852 acres of Laguna bottom would be completely covered for PAs 185–191. Of this total, it is estimated that 767 acres would be seagrass and 85 acres would be unvegetated bay bottom. There are 42 coastal cabins on existing placement areas in Reach 1. However, due to the large amount of emergent area available, it appears that only four of them would be affected by construction of open-bay semiconfined placement areas. Additionally, piping plovers were found on six placement areas in Reach 1 (EH&A, 1993). However, due to the amount of available emergent area versus the much smaller amount of area needed for semiconfined placement, it would appear that none of these sites will be impacted. There would be 1,376 dredging/construction days and 10,320 pipeline-mile days for Reach 1 over the 50-year period.

TABLE 2-21

ACREAGE BY PLACEMENT AREA FOR SEMICONFINED OPEN-BAY PLACEMENT FOR REACH 1

PA	Total Area	Emergent Area	Area Required for Semiconfined Placement	Additional Area Required
175	29.1	28.4	0.0*	0
176	133.8	113.4	10.9	0
177	35.8	27.0	6.3	0
178	125.3	78.6	16.4	0
179	40.1	23.9	5.5	0
180	125.6	76.1	46.5	0
181	96.6	58.9	35.5	0
182	58.5	36.5	17.3	0
183	152.1	59.3	24.4	0
184	98.7	43.9	30.3	0
185	105.4	33.6	46.3	12.7
186	117.4	2.4	98.3	95.9
187	137.8	0.0	188.0	188.0
188	165.8	0.0	213.8	213.8
189	124.7	0.0	174.3	174.3
190	69.9	0.0	101.7	101.7
191	57.3	0.0	65.9	65.9
Total	1,673.9	582.0	1,081.5	852.2

* Never used.

Reach 2. This reach contains PAs 192–202. For this reach, the same information as for Reach 1 is provided below (Table 2-22). Overall, semiconfined placement would require approximately 1,646 acres, if it is assumed that the three levees are built to a total height of 15 feet. Bay impacts would occur from the construction of the additional levees and from runoff from the placement areas. A minimum of 1,335 acres of Laguna bottom would be completely covered to create the semiconfined placement areas. Of this, it is estimated that 648 acres would be seagrass and 687 acres would be unvegetated bay bottom. There are 33 coastal cabins on existing placement areas in Reach 2, all of which would be demolished with the construction of open-bay semiconfined placement areas. Piping plovers were found on two placement areas in Reach 2 (EH&A, 1993), and it would appear that all of that habitat would be covered by creation of the open-bay semiconfined placement areas. There would be 1,681 dredging/construction days and 13,616 pipeline-mile days for Reach 2 over the 50-year period.

TABLE 2-22

ACREAGE BY PLACEMENT AREA FOR SEMICONFINED OPEN-BAY PLACEMENT FOR REACH 2

PA	Total Area	Emergent Area	Area Required for Semiconfined Placement	Additional Area Required
192	90.6	0.0	57.3	57.3
193	90.6	38.0	58.8	20.8
194	121.5	24.6	80.8	56.2
195	103.0	0.3	73.6	73.39
196	103.0	41.2	54.2	13.0
197	304.4	80.4	369.1	288.7
198	146.2	0.0	181.8	181.8
199	124.9	0.0	184.3	184.3
200	196.2	5.1	183.0	177.9
201	173.7	0.0	198.3	198.3
202	195.6	121.1	204.5	83.4
Total	1,649.7	310.7	1,645.6	1,334.9

Reach 3. This reach contains PAs 203–210, all in the Land Cut (Table 2-23). Overall, semiconfined placement would require approximately 974 acres, if it is assumed that the three levees are built only to a total height of 15 feet. Substantial bay impacts would occur since, to achieve open-bay confined placement in Reach 3, semiconfined areas would have to be created in The Hole, an open-water fishing area east of the northern portion of the Land Cut. Bay impacts would occur from the construction of the additional levees and from runoff from the placement areas. A minimum of 974 acres of Laguna bottom, including an estimated 633 acres of seagrass and 341 acres of algal/sand flats, would be completely covered to create the semiconfined placement areas. Channels would have to be dredged into The Hole to provide access for equipment for levee construction. There are 38 coastal cabins on existing placement areas in Reach 3, but none would be impacted by construction of open-bay semiconfined placement areas. No piping plovers were found in Reach 3 (EH&A, 1993, 1997b). There would be 1,752 dredging/construction days and 24,532 pipeline-mile days for Reach 3 over the 50-year period.

Reach 4. This reach contains PAs 211–222. The same information, as for Reach 1, is provided below (Table 2-24). Overall, semiconfined placement would require approximately 1,807.2 acres, if it is assumed that the three levees are built to a total height of 15 feet. Bay impacts would occur from the construction of the additional levees and from runoff from the placement areas. A minimum of 1,646 acres of Laguna bottom would be completely covered to create the semiconfined placement areas. Of this, it is estimated that 623 acres would be seagrass and 1,023 acres would be unvegetated bay bottom. There are 6 coastal cabins on existing placement areas in Reach 4, all of which would be demolished with the construction of open-bay semiconfined placement areas. No piping plovers were found in Reach 4 (EH&A, 1997b). There would be 2,070 dredging/construction days and 2,418 pipeline-mile days for Reach 4 over the 50-year period.

TABLE 2-23

ACREAGE BY PLACEMENT AREA FOR SEMICONFINED OPEN-BAY PLACEMENT FOR REACH 3

PA	Total Area	Emergent Area	Area Required for Semiconfined Placement	Additional Area Required
203	324.5	311.3	72.1	72.1 *
204	167.7	167.7	35.9	35.9
206	380.4	380.4	130.4	130.4
207	322.2	322.2	191.8	191.8
208	769.0	767.0	415.6	415.6
209	193.4	193.4	48.4	48.4
210	242.8	240.7	80.1	80.1
Total	2,400.0	2,382.7	974.1	974.1

* Emergent areas of existing PAs is not applicable for this reach since all PAs would be moved to The Hole.

TABLE 2-24

ACREAGE BY PLACEMENT AREA FOR SEMICONFINED OPEN-BAY PLACEMENT FOR REACH 4

PA	Total Area	Emergent Area	Area Required for Semiconfined Placement	Additional Area Required
211	140.8	45.4	136.7	91.3
212	192.1	0.0	204.4	204.4
213	191.7	0.0	116.7	116.7
214	191.4	0.0	157.1	157.1
215	194.1	0.0	176.3	176.3
216	194.7	0.0	75.5	75.5
217	193.3	0.0	116.2	116.2
218	194.3	0.0	208.9	208.9
219	119.8	0.0	93.7	93.7
220	216.1	2.0	128.5	128.5
221	387.2	63.3	247.3	184.0
222	259.4	52.6	145.9	93.3
Total	2,474.9	161.3	1,807.2	1,645.9

Reach 5. This reach contains PAs 223–228. The same information, as for Reach 1, is provided below (Table 2-25). Overall, semiconfined placement would require approximately 240 acres, if it is assumed that the three levees are built to a total height of 15 feet. Bay impacts would occur from the construction of the additional levees and from runoff from the placement areas. No acres of Laguna bottom would be covered to create the semiconfined placement areas. There are 14 coastal cabins on existing placement areas in Reach 5. However, due to the large amount of emergent area available, it appears that none of them would be affected by construction of open-bay semiconfined placement areas. No piping plovers were found in Reach 5 (EH&A, 1997b). There would be 223 dredging/ construction days and 1,337 pipeline-mile days for Reach 5.

TABLE 2-25

ACREAGE BY PLACEMENT AREA FOR SEMICONFINED OPEN-BAY PLACEMENT FOR REACH 5

PA	Total Area	Emergent Area	Area Required for Semiconfined Placement	Additional Area Required
223	158.8	137.4	41.4	0.0
224	175.4	172.3	15.2	0.0
225	84.3	77.6	8.3	0.0
226	257.6	247.6	85.4	0.0
227	65.4	43.0	38.3	0.0
228	294.4	115.1	51.6	0.0
Total	1,035.9	793.0	240.2	0.0

Reach 6. This reach contains PAs 229–239. The same information, as for Reach 1, is provided below (Table 2-26). Overall, semiconfined placement would require roughly 1,338 acres, if it is assumed that the levees are built to a total height of 15 feet. Bay impacts would occur from the construction of the additional levees and from runoff from the placement areas. Except for PAs 233 and 234, minimal unvegetated bay bottom would be impacted to create the semiconfined, open-bay placement areas, but a minimum of 1,251 acres of Laguna bottom would be completely covered if PAs 233 and 234 are included. As past experience has shown, even if it were found desirable, creating open-bay, semiconfined placement areas at PAs 233 and 234 could be a difficult task. Of the total acres, it is estimated that 500 would be seagrass and 751 would be unvegetated bay bottom. There are 11 coastal cabins on existing placement areas in Reach 6. However, due to the large amount of emergent area available, it appears that none of them would be affected by construction of open-bay semiconfined placement areas. No piping plovers were found in Reach 6 (EH&A, 1997b). There would be 472 dredging/construction days and 3,305 pipeline-mile days for Reach 6.

TABLE 2-26

ACREAGE BY PLACEMENT AREA FOR SEMICONFINED OPEN-BAY PLACEMENT FOR REACH 6

PA	Total Area	Emergent Area	Area Required for Semiconfined Placement	Additional Area Required
229	129.2	50.4	8.5	0.0
230	82.5	46.5	4.7	0.0
231	127.8	67.0	7.1	0.0
232	127.4	52.5	57.5	5.0
233	210.0	14.7	747.3	732.6
234	121.6	0.0	455.3	455.3
235	121.6	0.0	18.6	18.6
236	129.1	0.0	0.1	0.1
239	49.38	0.0	39.1	39.1
Total	1,098.6	231.1	1,338.2	1,250.7

2.10 RESULTS OF THE MATRIX ANALYSIS

A summary of the information used and the point values assigned are summarized below. As noted in Section 2.8.1, all point values are based on comparisons relative to the impacts of the present practice.

2.10.1 Reach 1

The discussion in this section is based on the scoring criteria presented in Section 2.8.2. The results of the Matrix are summarized in Table 2-27.

2.10.1.1 Dredging Action

The Dredging Action column is based on the acres of the receptors, except for Water Column Effects and Human Uses. Since all maintenance dredging occurs in the GIWW, no acres of any receptor are impacted and therefore, the score for all options is 0. For Water Column Impacts, the turbidity and toxicity effects, if there were any, would be the same for all options during the dredging phase and all scores are 0.

Human Use impacts are based on the number of dredging/construction days, which is 423 for the present practice, Open-Bay Unconfined (OBUn). For Open-Bay Confined (OBC – 654 days or 231 > OBUn) and Open-Bay Semiconfined (OBSC – 615 days or 192 > OBUn), the number of days is within the range of 101 to 500 greater than OBUn, leading to scores of –1. For Upland Confined (UpC – 926 days or 503 days > OBUn) and Upland Thin Layer (UpTL – with the same numbers), the number of

TABLE 2-27

MATRIX SUMMARY FOR REACH 1

Receptor	Option	Dredging Impact	Dredging Score	Conveyance Impact	Conveyance Score	Placement Impact	Placement Score	Post-placement Impact	Post-placement Score	Total Score
Seagrass	OBUn	0 ac	0.0	0 ac	0.0	711 ac	0.0	178 Long term ac 0 20% isopleth ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	570 ac	2.0	570 Permanent ac 0 20% isopleth ac	-1.0	**1.0**
	OBSC	0 ac	0.0	0 ac	0.0	617 ac	1.0	617 Permanent ac 0 20% isopleth ac	-1.0	**0.0**
	UpC	0 ac	0.0	23 ac	-1.0	0 ac	2.0	23 Long term ac 0 20% isopleth ac	1.0	**2.0**
	UpTL	0 ac	0.0	23 ac	-1.0	0 ac	2.0	23 Long term ac 0 20% isopleth ac	1.0	**2.0**
	OcnP	0	0.0	61 ac	-1.0	0 ac	2.0	61 Long term ac 0 20% isopleth ac	1.0	**2.0**
Open-Bay Bottom	OBUn	0 ac	0.0	0 ac	0.0	79 ac	0.0	0 * ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	63 ac	1.0	63 Permanent ac	-1.0	**0.0**
	OBSC	0 ac	0.0	0 ac	0.0	68 ac	1.0	68 Permanent ac	-1.0	**0.0**
	UpC	0 ac	0.0	28 ac	-1.0	0 ac	1.0	28 Long term ac	-1.0	**-1.0**
	UpTL	0 ac	0.0	28 ac	-1.0	0 ac	1.0	28 Long term ac	-1.0	**-1.0**
	OcnP	0 ac	0.0	75 ac	-1.0	0 ac	1.0	75 Long term ac	-1.0	**-1.0**
* Benthos recover rapidly except very near PA										
Emergent Bay Habitat	OBUn	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac, 0 PP**	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac, 0 PP	0.0	**0.0**
	OBSC	0 ac	0.0	0 ac	0.0	0 ac	0.0	Temp creation, 0 PP	0.5	**0.5**
	UpC	0 ac	0.0	40 ac	-1.0	0 ac	0.0	40 Long term ac, 0 PP	-0.5	**-1.5**
	UpTL	0 ac	0.0	40 ac	-1.0	0 ac	0.0	40 Long term ac, 0 PP	-0.5	**-1.5**
	OcnP	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac, 0 PP	0.0	**0.0**
** Piping Plover Sites										
Terrestrial Habitat	OBUn	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	0 ac	0.0	Temp creation	1.0	**1.0**
	OBSC	0 ac	0.0	0 ac	0.0	0 ac	0.0	Temp creation	1.0	**1.0**
	UpC	0 ac	0.0	12 ac	-1.0	516 ac	-2.0	516 Permanent ac	-2.0	**-5.0**
	UpTL	0 ac	0.0	12 ac	-1.0	790 ac	-2.0	790 Improvement ac	2.0	**-1.0**
	OcnP	0 ac	0.0	59 ac	-1.0	0 ac	0.0	0 ac	0.0	**-1.0**
Water Column Effect	OBUn	0 ac	0.0	No booster channels	0.0	Turbidity, no volume loss	0.0	No long-term turbidity	0.0	**0.0**
	OBC	0 ac	0.0	No booster channels	0.0	No turbidity, volume loss	0.0	Reduce turbidity	0.0	**0.0**
	OBSC	0 ac	0.0	No booster channels	0.0	Turbidity, volume loss	-0.5	No long-term turbidity	0.0	**-0.5**
	UpC	0 ac	0.0	Booster channels	-1.0	No turbidity, no volume loss	0.5	Reduce turbidity	0.0	**-0.5**
	UpTL	0 ac	0.0	Booster channels	-1.0	No turbidity, no volume loss	0.5	Reduce turbidity	0.0	**-0.5**
	OcnP	0 ac	0.0	Booster channels	-1.0	Transfer turbidity, no volume loss	0.0	Reduce turbidity	0.0	**-1.0**
Human Uses	OBUn	423 days	0.0	423 pmd[a]	0.0	0 ac	0.0	Minimal TSS, 0 CC[b], no LTA[c]	0.0	**0.0**
	OBC	654 days	-1.0	4,904 pmd	-2.0	633 ac	-2.0	No TSS, 4 CC, no LTA	-0.3	**-5.3**
	OBSC	615 days	-1.0	4,615 pmd	-2.0	685 ac	-2.0	Minimal TSS, 4 CC, no LTA	-0.3	**-5.3**
	UpC	926 days	-2.0	6,483 pmd	-2.0	516 ac	-2.0	No TSS, 0 CC, LTA	-0.3	**-6.3**
	UpTL	926 days	-2.0	6,483 pmd	-2.0	790 ac	-2.0	No TSS, 0 CC, no LTA	0.0	**-6.0**
	OcnP	2,538 days	-3.0	93,923 pmd	-3.0	0 ac	0.0	No TSS, 0 CC, no LTA	0.0	**-6.0**

[a] pipeline-mile-days; [b] Coastal Cabins; [c] Long-term aesthetic effect

days is within the range of 501 to 1,000 greater than OBUn, leading to scores of –2. Ocean Placement by Pipeline (OcnP – 2,538 days) requires over 1,000 days more than OBUn, leading to a score of –3.

2.10.1.2 Conveyance Action

The Conveyance Action column is also based on the acres of the receptors, except for Water Column Effects and Human Uses. For all of the acre receptors (Seagrass, Open-Bay Bottom, Emergent Bay Habitat, Terrestrial Habitat), except Emergent Bay Habitat for OcnP, there are impacts from laying pipelines and dredging booster channels, which fall into the 1-to-100-acre range, leading to scores of –1. There are no water column effects from the other options, relative to the present practice, OBUn, except for those associated with the booster channel dredging for UpC, UpTL, and OcnP, which lead to scores of –1 for these three options. Except for OcnP, in Human Uses, with over 90,000 pipeline-man-days (pmd) and score of –3, the other options have more pmds than OBUn in the range of 2,501–10,000, generating scores of –2.

2.10.1.3 Placement Action

The Placement Action column is also based on the acres of the receptors, except for Water Column Effects and Human Uses. The guidance given in Section 2.8.2 and the fact that all options impact the same or fewer acres than does OBUn, lead to neutral or positive scores for Seagrass, Open-Bay Bottom, and Emergent Bay Habitats. UpC and UpTL impact 516 and 790 more acres of Terrestrial Habitat, respectively, than does OBUn, leading to scores of –2.

As noted in Section 2.8.2, no scores were based on toxicants in the elutriate, because there has been no evidence of problems since 1986. Therefore, only the reduction in turbidity, associated with OBC, UpC, and UpTL and the loss of water volume for plankton and nekton, associated with the creation of OBC and OBSC placement areas, led to Water Quality scoring. There is some turbidity associated with OBUn and OBSC, so the reduction of turbidity for UpC and UpTL led to partial scores of +1, while OcnP, by merely changing the location of the turbidity from the Laguna Madre to the Gulf, and OBSC received partial scores of 0. OBC and OBSC, which caused a volume loss for aquatic flora and fauna, received partial scores of –1, while UpC, UpTL, and OcnP, which caused no volume loss, received partial scores of 0. The averages of the partial scores are presented in Table 2-27.

Human Uses Impacts, for the Placement Action, were determined by the number of acres removed from existing uses by placement. The existing placement areas have been designated for OBUn, so OBUn removes 0 acres from existing practice. OBC and OBSC remove 633 and 685 acres of the Laguna Madre, respectively, from existing uses of fishing, boating, etc., leading to scores of –2 for being in the 101–1,000 acres-more-than-present-practice category. UpC and UpTL were also in this category, for the removal of Terrestrial Habitat from customary use, and also received scores of –2. Actual placement, by the OcnP option, should cause no Human Use impacts and a score of 0 was assigned to this option.

2.10.1.4 Post-Placement Action

The Post-Placement Action is a little more complicated because, as can be seen from Table 2-27, there are more types of impacts per receptor than for the other actions. For example, there is burial of 711 acres of seagrass by OBUn, but there is empirical evidence (Sheridan, 1999) that recovery occurs over 75 percent of this area between dredging cycles, so 25 percent of this, or 178 acres, is considered a long-term loss. OBC and OBSC, on the other hand, lead to permanent loss of seagrasses of 570 and 617 acres of seagrass, respectively, leading to partial scores of –2. The acres of seagrass lost to the booster pump channels for UpC and UpTL are less than the long-term acreage for OBUn, but are also long-term losses and probably permanent. Therefore, there is a gain in the 1-to-100-acre scoring range, leading to partial scores of +1 when UpC, UpTL, and OcnP are compared with OBUn. The computer model showed 0 acre between the isopleths for 20 percent irradiance reaching the seagrasses, with and without OBUn, and none would be expected for the other placement options. Therefore, all partial scores for irradiance are 0. The averages of the partial scores for direct impacts to seagrass and the indirect impacts, via irradiance, are presented in Table 2-27.

Research has shown that benthos recover rapidly, except in the immediate vicinity of the placement area (Sheridan, 1999). Therefore, the area of impact for post-placement for OBUn is not enough to change the permanent or long-term impacts of the other options from the 1-to-100-acre scoring range and all other options received a score of –1 for the Open-Bay Bottom receptor.

OBSC will allow temporary creation of Emergent Bay Habitat from Seagrass and Open-Bay Bottom and received a partial score of +1 for Emergent Bay Habitat, while UpC and UpTL each cause a long-term loss of 40 acres and received a partial score of –1. OBC and OcnP affected 0 acres of Emergent Bay Habitat, leading to partial scores of 0. No piping plover sites are impacted by any option, leading to partial scores of 0. Averages of the partial scores for each option are presented in Table 2-27.

OBC and OBSC will allow temporary creation of Terrestrial Habitat for scores of +1. UpC will permanently remove 516 acres of Terrestrial Habitat from customary usage for a –2, whereas UpTL should improve 790 acres (see Section 2.9.3.2) for a +2.

All Water Column scores are 0 since, while there is turbidity associated with OBUn, the seagrass model showed no long-term difference between the with- and without-placement scenarios and the sediment transport model showed a sharp decrease in the difference between the with- and without-placement turbidity within a few months. Therefore, the fact that some other options reduce that turbidity is not a quantifiable benefit.

For impacts to Human Uses, all of the options produce minimal to no TSS, according to the models, so the only scoring comes from the long-term aesthetic (LTA) impact of 292 acres of Upland Confined placement areas to a height of 32 feet and the loss of four coastal cabins from the OBC and OBSC options. For OBC, a partial score of 0, for no TSS, averaged with a partial score of –1, for the loss of four coastal cabins, and a 0 for no LTA impacts, leads to a final score of –0.3. The same is true for OBSC. For UpC, a partial score of 0, for no TSS, averaged with a partial score of 0 for the loss of no coastal cabins and a –1 for LTA impacts, also leads to a final score of –0.3. UpTL and OcnP generate no TSS, impact no coastal cabins, and have no LTA impacts, leading to final scores of 0.0.

2.10.2 Reach 2

The discussion in this section is based on the scoring criteria presented above in Section 2.8.2. The results of the Matrix are summarized in Table 2-28.

2.10.2.1 Dredging Action

The Dredging Action column is based on the acres of the receptors, except for Water Column Effects and Human Uses. Since all dredging occurs in the GIWW, no acres of any receptor are impacted and, therefore, the score for all options is 0. For Water Column Impacts, the turbidity and toxicity effects, if there are any, would be the same for all options during the dredging phase, and all scores are 0. Human Use impacts are based on the number of dredging/construction days, which is 808 for the present practice, OBUn. For OBC (1,058 days or 250 > OBUn) and OBSC (1,038 days or 230 > OBUn), the number of days is within the range of 101 to 500 greater than OBUn, leading to scores of –1. For UpC and UpTL (both 1,538 days or 730 > OBUn), the number of days is within the range of 501 to 1,000 greater than OBUn, leading to scores of –2.

2.10.2.2 Conveyance Action

The Conveyance Action column is also based on the acres of the receptors, except for Water Column Effects and Human Uses. For all of the acre receptors, there are impacts from laying pipelines and dredging booster channels, which fall into the 1 – 100 range, leading to scores of –1. There are no water column effects from the other options, relative to the present practice, OBUn, except for those associated with the booster channel dredging for UpC and UpTL, which leads to a score of –1 for these two options. For Human Uses, all options have more pmds than OBUn in the range of 2,501–10,000, generating scores of –2.

2.10.2.3 Placement Action

The Placement Action column is also based on the acres of the receptors, except for Water Column Effects and Human Uses. The guidance given in Section 2.8.2 and the fact that all options impact the same or fewer acres than does OBUn, lead to neutral or positive scores for Seagrass, Open-Bay Bottom, and Emergent Bay Habitats. UpC and UpTL impact 980 and 1,651 more acres of Terrestrial Habitat, respectively, than does OBUn, leading to scores of –2 and –3, respectively.

As noted in Section 2.8.2, no scores were based on toxicants in the elutriate because there has been no evidence of problems since 1986. Therefore, only the reduction in turbidity, associated with OBC, UpC, and UpTL and the loss of water volume for plankton and nekton, associated with the creation of OBC and OBSC placement areas, led to Water Quality scoring. There is some turbidity associated with OBUn and OBSC (partial score of 0), so the reduction of turbidity for UpC and UpTL led to partial scores of +1. OBC and OBSC, which caused a volume loss for aquatic flora and fauna, received

TABLE 2-28

MATRIX SUMMARY FOR REACH 2

Receptor	Option	Dredging Impact	Dredging Score	Conveyance Impact	Conveyance Score	Placement Impact	Placement Score	Post-placement Impact	Post-placement Score	Total Score
Seagrass	OBUn	0 ac	0.0	0 ac	0.0	802 ac	0.0	201 Long term ac 80 20% isopleth ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	681 ac	2.0	681 Permanent ac 0 20% isopleth ac	-0.5	**1.5**
	OBSC	0 ac	0.0	0 ac	0.0	749 ac	1.0	749 Permanent ac 0 20% isopleth ac	-0.5	**0.5**
	UpC	0 ac	0.0	8 ac	-1.0	0 ac	2.0	8 Long term ac 0 20% isopleth ac	1.5	**2.5**
	UpTL	0 ac	0.0	8 ac	-1.0	0 ac	2.0	8 Long term ac 0 20% isopleth ac	1.5	**2.5**
	OcnP									**N/A**
Open-Bay Bottom	OBUn	0 ac	0.0	0 ac	0.0	849 ac	0.0	0 * ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	721 ac	2.0	721 Permanent ac	-2.0	**0.0**
	OBSC	0 ac	0.0	0 ac	0.0	793 ac	1.0	793 Permanent ac	-2.0	**-1.0**
	UpC	0 ac	0.0	18 ac	-1.0	0 ac	2.0	18 Long term ac	-1.0	**0.0**
	UpTL	0 ac	0.0	18 ac	-1.0	0 ac	2.0	18 Long term ac	-1.0	**0.0**
	OcnP									**N/A**
* Benthos recover rapidly except very near PA										
Emergent Bay Habitat	OBUn	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac, 0 PP**	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac, 2 PP	-0.5	**-0.5**
	OBSC	0 ac	0.0	0 ac	0.0	0 ac	0.0	Temp creation, 2 PP	0.0	**0.0**
	UpC	0 ac	0.0	10 ac	-1.0	0 ac	0.0	10 Long term ac, 0 PP	-0.5	**-1.5**
	UpTL	0 ac	0.0	10 ac	-1.0	0 ac	0.0	10 Long term ac, 0 PP	-0.5	**-1.5**
	OcnP									**N/A**
** Piping Plover Sites										
Terrestrial Habitat	OBUn	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	0 ac	0.0	Temp creation	1.0	**1.0**
	OBSC	0 ac	0.0	0 ac	0.0	0 ac	0.0	Temp creation	1.0	**1.0**
	UpC	0 ac	0.0	1 ac	-1.0	980 ac	-2.0	980 Permanent ac	-2.0	**-5.0**
	UpTL	0 ac	0.0	1 ac	-1.0	1,651 ac	-3.0	1,651 Improvement ac	3.0	**-1.0**
	OcnP									**N/A**
Water Column Effect	OBUn	0 ac	0.0	No booster channels	0.0	Turbidity, no volume loss	0.0	No long-term turbidity	0.0	**0.0**
	OBC	0 ac	0.0	No booster channels	0.0	No turbidity, volume loss	0.0	Reduce turbidity	0.0	**0.0**
	OBSC	0 ac	0.0	No booster channels	0.0	Turbidity, volume loss	-0.5	No long-term turbidity	0.0	**-0.5**
	UpC	0 ac	0.0	Booster channels	-1.0	No turbidity, no volume loss	0.5	Reduce turbidity	0.0	**-0.5**
	UpTL	0 ac	0.0	Booster channels	-1.0	No turbidity, no volume loss	0.5	Reduce turbidity	0.0	**-0.5**
	OcnP									**N/A**
Human Uses	OBUn	808 days	0.0	808 pmd[a]	0.0	0 ac	0.0	Minimal TSS, 0 CC[b], no LTA[c]	0.0	**0.0**
	OBC	1,058 days	-1.0	8,567 pmd	-2.0	1,402 ac	-3.0	No TSS, 33 CC, no LTA	-0.7	**-6.7**
	OBSC	1,038 days	-1.0	8,412 pmd	-2.0	1,542 ac	-3.0	Minimal TSS, 33 CC, no LTA	-0.7	**-6.7**
	UpC	1,538 days	-2.0	10,767 pmd	-2.0	980 ac	-2.0	No TSS, 0 CC, LTA	-0.3	**-6.3**
	UpTL	1,538 days	-2.0	10,767 pmd	-2.0	1,651 ac	-3.0	No TSS, 0 CC, no LTA	0.0	**-7.0**
	OcnP									**N/A**

a pipeline-mile-days; b Coastal Cabins; c Long-term aesthetic effect partial scores of –1, while UpC, UpTL, and OcnP, which caused no volume loss, received partial scores of 0. The averages of the partial scores are presented in Table 2-28.

Human Uses impacts, for the Placement Action, were determined by the number of acres removed from existing uses by placement. The existing placement areas have been designated for OBUn, so OBUn removes 0 acres from existing practice. OBC and OBSC remove 1,402 and 1,542 acres of the Laguna Madre, respectively, from existing uses of fishing, boating, etc., leading to scores of –3 for being in the >1,000 acre category. UpTL was also in this category, for the removal of 1,651 acres of Terrestrial Habitat from customary use, while UpC removes 980 acres and received a score of –2.

2.10.2.4 Post-Placement Action

The Post-Placement Action is a little more complicated because, as can be seen from Table 2-28, there are more types of impacts per receptor than for the other actions. For example, there is burial of 802 acres of seagrass by OBUn, but there is empirical evidence (Sheridan, 1999) that recovery occurs over 75 percent of this area between dredging cycles, so 25 percent of this is considered a long-term loss. OBC and OBSC, on the other hand, lead to permanent loss of seagrasses of 681 and 749 acres of seagrass, respectively, leading to partial scores of –2, while UpC and UpTL impacted fewer long-term acres of seagrass (101–1,000 acre category) for partial scores of +2. However, the computer models showed 80 acres between the isopleths for 20 percent irradiance reaching the seagrasses, with and without OBUn. It was assumed that there would be no acreage differences between isopleths for the other options, so they received partial scores of +1, based on the acreage between the isopleths. The average of partial scores of –2 and +1 is –0.5, for OBC and OBSC, and the average of +2 and +1 is +1.5, for UpC and UpTL.

Research has shown that benthos recover rapidly, except in the immediate vicinity of the placement area (Sheridan, 1999). Therefore, the area of impact for post-placement for OBUn is not enough to change the permanent or long-term impacts of the other options and, therefore, UpC and UpTL received a score of –1 for the Open-Bay Bottom receptor, while OBC and OBSC received scores of –2.

OBC affected 0 acres of Emergent Bay Habitat, but led to the loss of two piping plover sites, leading to a final average of –0.5. OBSC will allow temporary creation of Emergent Bay Habitat from Seagrass and Open-Bay Bottom and received a partial score of +1. However, OBSC also led to a loss of two piping plover sites for a partial score of –1 for piping plover sites, and a final score of 0 for Emergent Bay Habitat. UpC and UpTL each cause a long-term loss of 10 acres of Emergent Bay Habitat, while affecting no piping plover sites, for a final score of –0.5 (average of –1 and 0).

OBC and OBSC will allow temporary creation of Terrestrial Habitat for scores of +1. UpC will permanently remove 980 acres of Terrestrial Habitat from customary usage for a –2, whereas UpTL should improve 1,651 acres (see Section 2.9.3.2) for a +3.

All Water Column scores are 0 since, while there is turbidity associated with OBUn, the seagrass model showed no long-term difference between the with- and without-placement scenarios and the sediment transport model showed a sharp decrease in the difference between the with- and without-placement turbidity within a few months. Therefore, the fact that some other options reduce that turbidity is not a quantifiable benefit.

For impacts to Human Uses, all of the options produce minimal to no TSS, according to the models, so the only scoring comes from the long-term aesthetic (LTA) impact of 980 acres of Upland Confined placement areas to a height of 32 feet and the loss of 33 coastal cabins from the OBC and OBSC options. For OBC, a partial score of 0, for no TSS, averaged with a partial score of –2, for the loss of 33 coastal cabins, and 0 for no LTA impacts, leads to a final score of –0.7. The same is true for OBSC. For UpC, a partial score of 0, for no TSS, averaged with a partial score of 0, for the loss of no coastal cabins, and –1 for LTA impacts, leads to a final score of –0.3. UpTL generates no TSS, impacts no coastal cabins, and has no LTA impacts, leading to a final score of 0.0.

2.10.3 Reach 3

The discussion in this section is based on the scoring criteria presented above in Section 2.8.2. The results of the Matrix are summarized in Table 2-29.

2.10.3.1 Dredging Action

The Dredging Action column is based on the acres of the receptors, except for Water Column Effects and Human Uses. Since all dredging occurs in the GIWW, no acres of any receptor are impacted and therefore, the score for all options is 0. For Water Column Impacts, the turbidity and toxicity effects, if there are any, would be the same for all options during the dredging phase, and all scores are 0. Human Use impacts are based on the number of dredging/construction days which is 528 for the present practice, UpC. UpTL is not feasible for this reach (Section 2.9.3.2). For the three remaining options, OBUn, OBC, and OBSC, the number of days required for dredging and construction in the range of 501 to 1,000 greater than UpC, leading to scores of –2.

2.10.3.2 Conveyance Action

The Conveyance Action column is also based on the acres of the receptors, except for Water Column Effects and Human Uses. Since upland areas, designated as placement areas, occur adjacent to the GIWW in Reach 3, the impacts from laying pipelines and dredging booster channels to seagrasses, open-bay bottom, and emergent bay habitat, that are found in the other reaches, do not occur in Reach 3. Therefore, the acreages and scores are 0 for conveyance for these receptors. There are no water column effects from the other options, relative to the present practice, UpC, since all boosters will be located on uplands, which leads to a score of 0 for all of these options. For Human Uses, the other options have over 10,000 more pmds than UpC, generating scores of –3.

2.10.3.3 Placement Action

The Placement Action column is also based on the acres of the receptors, except for Water Column Effects and Human Uses. The guidance given in Section 2.8.2 and the fact that all options impact between 100 – 1,000 more acres of Seagrass and Emergent Bay Habitat than does UpC, lead to

TABLE 2-29

MATRIX SUMMARY FOR REACH 3

Receptor	Option	Dredging Impact	Dredging Score	Conveyance Impact	Conveyance Score	Placement Impact	Placement Score	Post-placement Impact	Post-placement Score	Total
					Action					
Seagrass	OBUn	0 ac	0.0	0 ac	0.0	630 ac	-2.0	158 Long term ac 0 20% isopleth ac	-1.0	**-3.0**
	OBC	0 ac	0.0	0 ac	0.0	770 ac	-2.0	770 Permanent ac 0 20% isopleth ac	-1.0	**-3.0**
	OBSC	0 ac	0.0	0 ac	0.0	793 ac	-2.0	793 Permanent ac 0 20% isopleth ac	-1.0	**-3.0**
	UpC	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 Long term ac 0 20% isopleth ac	0.0	**0.0**
	UpTL									**N/A**
	OcnP									**N/A**
Open-Bay Bottom	OBUn	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 * ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 Permanent ac	0.0	**0.0**
	OBSC	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 Permanent ac	0.0	**0.0**
	UpC	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 Long term ac	0.0	**0.0**
	UpTL									**N/A**
	OcnP									**N/A**
* Benthos recover rapidly except very near PA										
Emergent Bay Habitat	OBUn	0 ac	0.0	0 ac	0.0	340 ac	-2.0	0 ac, 0 PP**	0.0	**-2.0**
	OBC	0 ac	0.0	0 ac	0.0	415 ac	-2.0	0 ac, 0 PP	0.0	**-2.0**
	OBSC	0 ac	0.0	0 ac	0.0	427 ac	-2.0	Temp creation, 0 PP	0.5	**-1.5**
	UpC	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 Long term ac, 0 PP	0.0	**0.0**
	UpTL									**N/A**
	OcnP									**N/A**
** Piping Plover Sites										
Terrestrial Habitat	OBUn	0 ac	0.0	0 ac	0.0	0 ac	2.0	0 ac	0.0	**2.0**
	OBC	0 ac	0.0	0 ac	0.0	0 ac	2.0	Temp creation	1.0	**3.0**
	OBSC	0 ac	0.0	0 ac	0.0	0 ac	2.0	Temp creation	1.0	**3.0**
	UpC	0 ac	0.0	0 ac	0.0	776 ac	0.0	0 Permanent ac	0.0	**0.0**
	UpTL									**N/A**
	OcnP									**N/A**
Water Column Column Effect	OBUn	0 ac	0.0	No booster channels	0.0	Turbidity, no volume loss	-0.5	No long-term turbidity	0.0	**-0.5**
	OBC	0 ac	0.0	No booster channels	0.0	No turbidity, volume loss	-0.5	Reduce turbidity	0.0	**-0.5**
	OBSC	0 ac	0.0	No booster channels	0.0	Turbidity, volume loss	-1.0	No long-term turbidity	0.0	**-1.0**
	UpC	0 ac	0.0	No booster channels	0.0	No turbidity, no volume loss	0.0	Reduce turbidity	0.0	**0.0**
	UpTL									**N/A**
	OcnP									**N/A**
Human Uses	OBUn	1,227 days	-2.0	17,182 pmd[a]	-3.0	243 ac	-2.0	Minimal TSS, 0 CC[b], no LTA[c], no impacts to the Hole	0.0	**-7.0**
	OBC	1,136 days	-2.0	15,909 pmd	-3.0	1,185 ac	-3.0	No TSS, 0 CC, no LTA, impacts to The Hole	-0.3	**-8.3**
	OBSC	1,045 days	-2.0	14,636 pmd	-3.0	1,220 ac	-3.0	Minimal TSS, 0 CC, no LTA, impacts to The Hole	-0.3	**-8.3**
	UpC	528 days	0.0	528 pmd	0.0	0 ac	0.0	No TSS, 0 CC, no LTA, no impacts to The Hole	0.0	**0.0**
	UpTL									**N/A**
	OcnP									**N/A**

[a] pipeline-mile-days; [b] Coastal Cabins; [c] Long-term aesthetic effect

scores of –2 for these receptors. No Open-Bay Bottom is affected by any option and the scores are 0. UpC impacts 776 acres of Terrestrial Habitat, while the other options affect none, leading to scores of +2 for all other options.

As noted in Section 2.8.2, no scores were based on toxicants in the elutriate because there was no evidence of problems since 1986. Therefore, only the increase in turbidity associated with OBSC and OBUn (partial score of –1) and the volume loss associated with OBC and OBSC (partial score of –1) led to Water Quality scoring. The average of the partial scores, –0.5, for OBUn and OBC, and –1.0, for OBSC, are included in Table 2-29.

Scores for Human Uses were determined by the number of acres removed from existing uses, by placement. Since the placement areas in Reach 3, where UpC placement would occur have been designated for placement of dredged material, UpC would remove 0 acres from previous usage. OBC and OBSC would remove 1,185 and 1,220 acres of the Laguna Madre, respectively, from existing uses of fishing, boating, etc., leading to scores of –3 for being in the >1,000 acre category. OBUn is estimated to have some impact on 970 acres of Laguna Madre that is used for fishing, boating, etc., 25 percent, or 243 acres, of which is considered long term (see Section 2.9.5.1) leading to a score of –2.

2.10.3.4 Post-Placement Action

The Post-Placement Action is a little more complicated because, as can be seen from Table 2-29, there are more types of impacts per receptor than for the other actions. For example, there is burial of 630 acres of seagrass by OBUn, but there is empirical evidence (Sheridan, 1999) that recovery occurs over 75 percent of this area between dredging cycles, so 25 percent of this is considered a long-term loss. Since UpC impacts no seagrass, OBUn received a partial score of –2. OBC and OBSC, on the other hand, lead to permanent loss of 770 and 793 acres of seagrass, respectively, leading to partial scores of -2. The model provided no information on the acreage difference between the 20 percent irradiance isopleths, with and without placement by OBUn, because OBUn has never been used in this reach and there are no historical data with which to compare. However, based on the high sand content of Reach 3 sediment, it was assumed that OBUn placement in The Hole would lead to essentially no turbidity, and no difference in irradiance acres. Based on the assumption of 0 acres, OBUn would receive a partial score of 0 for irradiance differences. The average of the partial scores of –2 for seagrass acreage and 0 for irradiance, leads to a final score of –1.0 for OBUn, OBC, and OBSC.

Research has shown that benthos recover rapidly, except in the immediate vicinity of the placement area (Sheridan, 1999). Therefore, the area of impact for post-placement for OBUn is not enough to assign a negative score to this option and all options received a score of 0 for Open-Bay Bottom. OBSC will allow temporary creation of Emergent Bay Habitat from Seagrass and Open-Bay Bottom and received a partial score of +1 for Emergent Bay Habitat, while all other options affected no Emergent Bay Habitat and received a partial score of 0. No piping plover sites are impacted by any option, leading to partial scores of 0. Averages of the partial scores for each option are presented in Table 2-29.

UpC will impact 776 acres of Terrestrial Habitat but it has all been designated for that use. OBC and OBSC will allow temporary creation of Terrestrial Habitat from seagrass and Emergent Bay Habitat for scores of +1. OBUn will affect no Terrestrial Habitat for a score of 0.

All Water Column scores are 0 since, while there is turbidity associated with OBUn, the seagrass model showed no long-term difference between the with- and without-placement scenarios, and the sediment transport model showed a sharp decrease in the difference between the with- and without-placement turbidity within a few months for the other reaches. Therefore, the fact that it induces turbidity relative to UpC is not a quantifiable impact.

For impacts to Human Uses, all of the options produce minimal to no TSS, according to the models, so the only scoring comes from the long-term impacts to The Hole by OBC and OBSC (partial score of –1). Since the Upland Confined placement areas are already in existence, there are no long-term aesthetic (LTA) impacts from UpC in Reach 3, as there would be in other reaches. No coastal cabins are impacted by any placement option. Therefore, OBUn and UpC generate no TSS, impact no coastal cabins, have no LTA impacts, and cause no impacts to The Hole for a final score of 0. OBC and OBSC are the same except for impacts to The Hole for final average scores of –0.25, which rounds to –0.3.

2.10.4 Reach 4

The discussion in this section is based on the scoring criteria presented above in Section 2.8.2. The results of the Matrix are summarized in Table 2-30.

2.10.4.1 Dredging Action

The Dredging Action column is based on the acres of the receptors, except for Water Column Effects and Human Uses. Since all dredging occurs in the GIWW, no acres of any receptor are impacted, and therefore, the score for all options is 0. For Water Column Impacts, the turbidity and toxicity effects, if there are any, would be the same for all options during the dredging phase, and all scores are 0. Human Use impacts are based on the number of dredging/construction days, which is 969 for the present practice, OBUn. For OBC (1,594 days or 625 > OBUn) and OBSC (1,500 days or 531 > OBUn), the number of days is within the range of 501 to 1,000 greater than OBUn, leading to scores of –2. For UpC and UpTL (both 2,043 days or 1,074 > OBUn), the number of days is more than 1,000 days greater than OBUn, leading to scores of –3.

2.10.4.2 Conveyance Action

The Conveyance Action column is also based on the acres of the receptors, except for Water Column Effects and Human Uses. For all of the acre receptors, there are impacts from laying pipelines and dredging booster channels for UpC and UpTL, which fall into the 1 – 100 range, leading to scores of –1 for these two options. There are no water column effects from the other options, relative to the present practice, OBUn, except for those associated with the booster channel dredging for UpC and UpTL, which leads to a score of –1 for these two options. For Human Uses, OBC and OBSC have more

Table 2-30

Matrix Summary for Reach 4

Receptor	Option	Action: Dredging Impact	Dredging Score	Conveyance Impact	Conveyance Score	Placement Impact	Placement Score	Post-placement Impact	Post-placement Score	Total
Seagrass	OBUn	0 ac	0.0	0 ac	0.0	429 ac	0.0	107 Long term ac 131 20% isopleth ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	643 ac	-2.0	643 Permanent ac 0 20% isopleth ac	0.0	**-2.0**
	OBSC	0 ac	0.0	0 ac	0.0	699 ac	-2.0	699 Permanent ac 0 20% isopleth ac	0.0	**-2.0**
	UpC	0 ac	0.0	40 ac	-1.0	0 ac	2.0	40 Long term ac 0 20% isopleth ac	1.5	**2.5**
	UpTL	0 ac	0.0	40 ac	-1.0	0 ac	2.0	40 Long term ac 0 20% isopleth ac	1.5	**2.5**
	OcnP									**N/A**
Open-Bay Bottom	OBUn	0 ac	0.0	0 ac	0.0	704 ac	0.0	0 * ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	1,056 ac	-2.0	1,056 Permanent ac	-3.0	**-5.0**
	OBSC	0 ac	0.0	0 ac	0.0	1,149 ac	-2.0	1,149 Permanent ac	-3.0	**-5.0**
	UpC	0 ac	0.0	59 ac	-1.0	0 ac	2.0	59 Long term ac	-1.0	**0.0**
	UpTL	0 ac	0.0	59 ac	-1.0	0 ac	2.0	59 Long term ac	-1.0	**0.0**
	OcnP									**N/A**

* Benthos recover rapidly except very near PA

Receptor	Option	Dredging Impact	Dredging Score	Conveyance Impact	Conveyance Score	Placement Impact	Placement Score	Post-placement Impact	Post-placement Score	Total
Emergent Bay Habitat	OBUn	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac, 0 PP**	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac, 0 PP	0.0	**0.0**
	OBSC	0 ac	0.0	0 ac	0.0	0 ac	0.0	Temp creation, 0 PP	0.5	**0.5**
	UpC	0 ac	0.0	16 ac	-1.0	0 ac	0.0	16 Long term ac, 0 PP	-0.5	**-1.5**
	UpTL	0 ac	0.0	16 ac	-1.0	0 ac	0.0	16 Long term ac, 0 PP	-0.5	**-1.5**
	OcnP									**N/A**

** Piping Plover Sites

Receptor	Option	Dredging Impact	Dredging Score	Conveyance Impact	Conveyance Score	Placement Impact	Placement Score	Post-placement Impact	Post-placement Score	Total
Terrestrial Habitat	OBUn	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	0 ac	0.0	Temp creation	1.0	**1.0**
	OBSC	0 ac	0.0	0 ac	0.0	0 ac	0.0	Temp creation	1.0	**1.0**
	UpC	0 ac	0.0	9 ac	-1.0	1,123 ac	-3.0	1,123 Permanent ac	-3.0	**-7.0**
	UpTL	0 ac	0.0	9 ac	-1.0	1,133 ac	-3.0	1,133 Improvement ac	3.0	**-1.0**
	OcnP									**N/A**
Water Column Effects	OBUn	0 ac	0.0	ooster char	0.0	ty, no volu	0.0	No long-term turbidity	0.0	**0.0**
	OBC	0 ac	0.0	ooster char	0.0	No	0.0	Reduce turbidity	0.0	**0.0**
	OBSC	0 ac	0.0	ooster char	0.0	Turbidity,	-0.5	No long-term turbidity	0.0	**-0.5**
	UpC	0 ac	0.0	oster chann	-1.0	No	0.5	Reduce turbidity	0.0	**-0.5**
	UpTL	0 ac	0.0	oster chann	-1.0	No	0.5	Reduce turbidity	0.0	**-0.5**
	OcnP									**N/A**
Human Uses	OBUn	969 days	0.0	969 pmd[a]	0.0	0 ac	0.0	Minimal TSS, 0 CC[b], no LTA[c]	0.0	**0.0**
	OBC	1,594 days	-2.0	9,563 pmd	-2.0	1,699 ac	-3.0	No TSS, 6 CC, no LTA	-0.3	**-7.3**
	OBSC	1,500 days	-2.0	9,000 pmd	-2.0	1,848 ac	-3.0	inimal TSS, 6 CC, no LT	-0.3	**-7.3**
	UpC	2,043 days	-3.0	14,298 pmd	-3.0	1,123 ac	-3.0	No TSS, 0 CC, LTA	-0.3	**-9.3**
	UpTL	2,043 days	-3.0	14,298 pmd	-3.0	1,133 ac	-3.0	No TSS, 0 CC, no LTA	0.0	**-9.0**
	OcnP									**N/A**

[a] pipeline-mile-days; [b] Coastal Cabins; [c] Long-term aesthetic effect

pmds than OBUn in the range of 2,501 – 10,000, generating scores of –2. UpC and UpTL have more than 10,000 pmds greater than OBUn, generating scores of –3 for these two options.

2.10.4.3 Placement Action

The Placement Action column is also based on the acres of the receptors, except for Water Column Effects and Human Uses. OBC and OBSC impact more Seagrass and Open-Bay Bottom than does OBUn, in the range of 100–1,000 acres, leading to scores of –2 for these two options for these two receptors. UpC and UpTL impact no Seagrass or Open-Bay Bottom during placement, so they received scores of +2 for these two receptors. No Emergent Bay Habitat was impacted during placement in Reach 4, so all options received scores of 0. UpC and UpTL impact 1,123 and 1,133 more acres of Terrestrial Habitat, respectively, than does OBUn, leading to scores of –3.

As noted in Section 2.8.2, no scores were based on toxicants in the elutriate because there was no evidence of problems since 1986. Therefore, only the reduction in turbidity, associated with OBC, UpC, and UpTL and the loss of water volume for plankton and nekton, associated with the creation of OBC and OBSC placement areas, led to Water Quality scoring. There is some turbidity associated with OBUn, so the reduction of turbidity for UpC and UpTL led to partial scores of +1. OBC, which reduced turbidity but caused a volume loss for aquatic flora and fauna (partial scores of +1 and –1), received a net score of 0 while OBSC, which caused the volume loss but did not reduce turbidity completely (partial scores of –1 and 0), received an average score of –0.5.

Human Uses impacts, for the Placement Action, were determined by the number of acres removed from existing uses by placement. The existing placement areas have been designated for OBUn, so OBUn removes 0 acres from existing practice. OBC and OBSC remove 1,699 and 1,848 acres of the Laguna Madre, respectively, from existing uses of fishing, boating, etc., leading to scores of –3 for being in the >1,000 acre category. UpC and UpTL were also in this category, for the removal of Terrestrial Habitat (1,133 acres and 1,123 acres, respectively) from customary use.

2.10.4.4 Post-Placement Action

The Post-Placement Action is a little more complicated because, as can be seen from Table 2-30, there are more types of impacts per receptor than for the other actions. For example, there is burial of 429 acres of seagrass by OBUn, but there is empirical evidence (Sheridan, 1999) that recovery occurs over 75 percent of this area between dredging cycles, so 25 percent of this is considered a long-term loss. OBC and OBSC, on the other hand, lead to permanent loss of seagrasses of 643 and 699 acres of seagrass, respectively, leading to partial scores of –2. However, the computer models showed 131 acres between the isopleths for 20 percent irradiance reaching the seagrasses, with and without OBUn. It was assumed that there would be no acreage differences between isopleths for the other options, so OBC and OBSC received partial scores of +2, based on the acreage between the isopleths. The average of partial scores of –2 and +2 is 0. Therefore, OBC and OBSC received final scores of 0.

The acres of seagrass lost to the booster pump channels for UpC and UpTL are less than the long-term acreage for OBUn, and is also long-term loss and probably permanent. Therefore, there is a seagrass gain in the 1-to-100-acre scoring range, leading to partial scores of +1 when UpC and UpTL are compared with OBUn. Averaged with the +2, based on the acreage between the isopleths, leads to final scores of +1.5 for UpC and UpTL.

Research has shown that benthos recover rapidly, except in the immediate vicinity of the placement area (Sheridan, 1999). Therefore, the area of impact for post-placement for OBUn is not enough to change the permanent or long-term impacts of the other options and UpC and UpTL received scores of –1 for the Open-Bay Bottom receptor (booster channels), while OBC and OBSC received scores of –3.

OBSC will allow temporary creation of Emergent Bay Habitat from Seagrass and Open-Bay Bottom and received a partial score of +1. OBC affected 0 acres of Emergent Bay Habitat, leading to a partial score of 0. UpC and UpTL each cause a long-term loss of 16 acres of Emergent Bay Habitat, leading partial scores of –1. No piping plover sites are impacted by any option, leading to partial scores on 0. Averages of the partial scores for each option are presented in Table 2-30.

OBC and OBSC will allow temporary creation of Terrestrial Habitat for scores of +1. UpC will permanently remove 1,123 acres of Terrestrial Habitat from customary usage for a –3, whereas UpTL should improve 1,133 acres (see Section 2.9.3.2) for a +3.

All Water Column scores are 0 since, while there is turbidity associated with OBUn, the seagrass model showed no long-term difference between the with- and without-placement scenarios, and the sediment transport model showed a sharp decrease in the difference between the with- and without-placement turbidity within a few months. Therefore, the fact that some other options reduce that turbidity is not a quantifiable benefit.

For impacts to Human Uses, all of the options produce minimal to no TSS, according to the models, so the only scoring comes from the long-term aesthetic (LTA) impact of 1,123 acres of Upland Confined placement areas, to a height of 33 feet, and the loss of 6 coastal cabins with OBC and OBSC. For OBC, a partial score of 0, for no TSS, averaged with a partial score of –1, for the loss of 6 coastal cabins, and 0 for no LTA impacts, leads to a final score of –0.3. The same is true for OBSC. For UpC, a partial score of 0, for no TSS, averaged with a partial score of 0, for the loss of no coastal cabins, and –1 for LTA impacts, leads to a final score of –0.3. UpTL generates no TSS, impacts no coastal cabins, and has no LTA impacts, leading to a final score of 0.0.

2.10.5 Reach 5

The discussion in this section is based on the scoring criteria presented above in Section 2.8.2. The results of the Matrix are summarized in Table 2-31.

Table 2-31

Matrix Summary for Reach 5

Receptor	Option	Action: Dredging Impact	Dredging Score	Conveyance Impact	Conveyance Score	Placement Impact	Placement Score	Post-placement Impact	Post-placement Score	Total
Seagrass	OBUn	0 ac	0.0	0 ac	0.0	139 ac	0.0	35 Long term ac, 10 20% isopleth ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	50 ac	1.0	50 Permanent ac 0 20% isopleth ac	0.0	**1.0**
	OBSC	0 ac	0.0	0 ac	0.0	56 ac	1.0	56 Permanent ac 0 20% isopleth ac	0.0	**1.0**
	UpC	0 ac	0.0	29 ac	-1.0	0 ac	2.0	29 Long term ac 0 20% isopleth ac	1.0	**2.0**
	UpTL	0 ac	0.0	29 ac	-1.0	0 ac	2.0	29 Long term ac 0 20% isopleth ac	1.0	**2.0**
	OcnP	0 ac	0.0	82 ac	-1.0	0 ac	2.0	82 Long term ac 0 20% isopleth ac	0.0	**1.0**
Open-Bay Bottom	OBUn	0 ac	0.0	0 ac	0.0	33 ac	0.0	0 * ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	12 ac	1.0	12 Permanent ac	-1.0	**0.0**
	OBSC	0 ac	0.0	0 ac	0.0	14 ac	1.0	14 Permanent ac	-1.0	**0.0**
	UpC	0 ac	0.0	10 ac	-1.0	0 ac	1.0	10 Long term ac	-1.0	**-1.0**
	UpTL	0 ac	0.0	10 ac	-1.0	0 ac	1.0	10 Long term ac	-1.0	**-1.0**
	OcnP	0 ac	0.0	0 ac	0.0	0 ac	1.0	0 Long term ac	0.0	**1.0**
* Benthos recover rapidly except very near PA										
Emergent Bay Habitat	OBUn	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac, 0 PP**	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac, 0 PP	0.0	**0.0**
	OBSC	0 ac	0.0	0 ac	0.0	0 ac	0.0	Temp creation, 0 PP	0.5	**0.5**
	UpC	0 ac	0.0	30 ac	-1.0	0 ac	0.0	30 Long term ac, 0 PP	-0.5	**-1.5**
	UpTL	0 ac	0.0	30 ac	-1.0	0 ac	0.0	30 Long term ac, 0 PP	-0.5	**-1.5**
	OcnP	0 ac	0.0	72 ac	-1.0	0 ac	0.0	72 ac, 0 PP	-0.5	**-1.5**
** Piping Plover Sites										
Terrestrial Habitat	OBUn	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	0 ac	0.0	Temp creation	1.0	**1.0**
	OBSC	0 ac	0.0	0 ac	0.0	0 ac	0.0	Temp creation	1.0	**1.0**
	UpC	0 ac	0.0	0 ac	0.0	176 ac	-2.0	176 Permanent ac	-2.0	**-4.0**
	UpTL	0 ac	0.0	0 ac	0.0	172 ac	-2.0	172 Improvement	2.0	**0.0**
	OcnP	0 ac	0.0	15 ac	-1.0	0 ac	0.0	15 Long term ac	-1.0	**-2.0**
Water Column Effect	OBUn	0 ac	0.0	No booster channels	0.0	Turbidity, no volume loss	0.0	No long-term turbidity	0.0	**0.0**
	OBC	0 ac	0.0	No booster channels	0.0	No turbidity, volume loss	0.0	Reduce turbidity	0.0	**0.0**
	OBSC	0 ac	0.0	No booster channels	0.0	Turbidity, volume loss	-0.5	No long-term turbidity	0.0	**-0.5**
	UpC	0 ac	0.0	Booster channels	-1.0	No turbidity, no volume loss	0.5	Reduce turbidity	0.0	**-0.5**
	UpTL	0 ac	0.0	Booster channels	-1.0	No turbidity, no volume loss	0.5	Reduce turbidity	0.0	**-0.5**
	OcnP	0 ac	0.0	Booster channels	-1.0	Transfer turbidity, no volume loss	0.0	Reduce turbidity	0.0	**-1.0**
Human Uses	OBUn	132 days	0.0	132 pmd[a]	0.0	0 ac	0.0	Minimal TSS, 0 CC[b], no LTA[c]	0.0	**0.0**
	OBC	316 days	-1.0	1,895 pmd	-1.0	62 ac	-1.0	No TSS, 0 CC, no LTA	0.0	**-3.0**
	OBSC	289 days	-1.0	1,737 pmd	-1.0	70 ac	-1.0	Minimal TSS, 0 CC, no LTA	0.0	**-3.0**
	UpC	566 days	-1.0	3,961 pmd	-2.0	176 ac	-2.0	No TSS, 0 CC, LTA	-0.3	**-5.3**
	UpTL	566 days	-1.0	3,961 pmd	-2.0	172 ac	-2.0	No TSS, 0 CC, no LTA	0.0	**-5.0**
	OcnP	1,132 days	-2.0	27,158 pmd	-3.0	0 ac	0.0	No TSS, 0 CC, no LTA	0.0	**-5.0**

[a] pipeline-mile-days; [b] Coastal Cabins; [c] Long-term aesthetic effect

2.10.5.1 Dredging Action

The Dredging Action column is based on the acres of the receptors, except for Water Column Effects and Human Uses. Since all dredging occurs in the GIWW, no acres of any receptor are impacted and, therefore, the score for all options is 0. For Water Column Impacts, the turbidity and toxicity effects, if there are any, would be the same for all options during the dredging phase, and all scores are 0. Human Use impacts are based on the number of dredging/construction days, which is 132 for the present practice, OBUn. For OBC (316 days or 184 > OBUn) and OBSC (289 days or 157 > OBUn), the number of days is within the range of 101 to 500 greater than OBUn, leading to scores of –1. For UpC and UpTL (both 566 days or 434 > OBUn), the number of days is also within the range of 101 to 500 greater than OBUn, leading to scores of –1. OcnP (1,132 days) requires exactly 1,000 days more than OBUn, leading to a score of –2.

2.10.5.2 Conveyance Action

The Conveyance Action column is also based on the acres of the receptors, except for Water Column Effects and Human Uses. For all of the acre receptors, there are impacts from laying pipelines and dredging booster channels, which fall into the 1 – 100 range, leading to scores of –1 for UpC, UpTL, and OcnP, for one or more receptors. There are no water column effects from the other options, relative to the present practice, OBUn, except for those associated with the booster channel dredging for UpC, UpTL, and OcnP, which leads to a score of –1 for these three options. For Human Uses, all options have more pmds than OBUn: in the range of 1,000 to 2,500 for OBC and OBSC for scores of –1; between 2,501 – 10,000, for UpC and UpTL, generating scores of –2; and >10,000 for OcnP, leading to a score of –3.

2.10.5.3 Placement Action

The Placement Action column is also based on the acres of the receptors, except for Water Column Effects and Human Uses. The guidance given in Section 2.8.2 and the fact that all options impact the same or fewer acres than does OBUn, lead to neutral or positive scores for Seagrass, Open-Bay Bottom, and Emergent Bay Habitats. UpC and UpTL impact 176 and 172 more acres of Terrestrial Habitat, respectively, than does OBUn, leading to scores of –2.

As noted in Section 2.8.2, no scores were based on toxicants in the elutriate because there was no evidence of problems since 1986. Therefore, only the reduction in turbidity, associated with OBC, UpC, and UpTL and the loss of water volume for plankton and nekton, associated with the creation of OBC and OBSC placement areas, led to Water Quality scoring. There is some turbidity associated with OBUn, so the reduction of turbidity for UpC and UpTL led to partial scores of +1. OBC, which reduced turbidity but caused a volume loss for aquatic flora and fauna, received a score of 0, while OBSC, which caused the volume loss but did not reduce turbidity completely, received a score of –0.5. OcnP, which only transferred the turbidity from the Laguna to the Gulf of Mexico but caused no volume loss, received a score of 0.

Scores for Human Uses were determined by the number of acres removed from existing uses by placement. The existing placement areas have been designated for OBUn, so OBUn removes 0 acres from existing practice. OBC and OBSC remove 62 and 70 acres of the Laguna Madre, respectively, from existing uses of fishing, boating, etc., leading to scores of –1 for being in the 1-to-100-acre category. UpC and UpTL removed 176 and 172 acres, respectively, and received scores of –2. OcnP removed 0 acres from existing uses and received a score of 0.

2.10.5.4 Post-Placement Action

The Post-Placement action is a little more complicated because, as can be seen from Table 2-31, there are more types of impacts per receptor than for the other actions. For example, there is burial of 139 acres of seagrass by OBUn, but there is empirical evidence (Sheridan, 1999) that recovery occurs over 75 percent of this area between dredging cycles, so 25 percent of this is considered a long-term loss. OBC and OBSC, on the other hand, lead to permanent losses of seagrass of 50 and 56 acres, respectively, leading to partial scores of –1. However, the computer models showed 10 acres between the isopleths for 20 percent irradiance reaching the seagrasses, with and without OBUn. It was assumed that there would be no acreage differences between isopleths for the other options, so OBC and OBSC received partial scores of +1, based on the acreage between the isopleths. The average of partial scores of –1 and +1 is 0. Therefore, OBC and OBSC received final scores of 0.

The acres of seagrass lost to the booster pump channels for OcnP is greater than the long-term acreage for OBUn, while the acres of seagrass lost to the booster pump channels for UpC and UpTL is less than the long-term acreage for OBUn, and are also long-term loss and probably permanent. Therefore, there is a loss in the 1-to-100-acre scoring range, leading to a partial score of –1 when OcnP is compared with OBUn but partial scores of +1 for UpC and UpTL. Averaged with the +1, based on the acreage between the isopleths, leads to a final score of 0 for OcnP and +1 for UpC and UpTL.

Research has shown that benthos recover rapidly, except in the immediate vicinity of the placement area (Sheridan, 1999). Therefore, the area of impact for post-placement for OBUn is not enough to change the permanent or long-term impacts of the other options and, all options except OcnP, which impacts no Open-Bay Bottom, received scores of –1. OBSC will allow temporary creation of Emergent Bay Habitat from Seagrass and Open-Bay Bottom and received a partial score of +1. UpC and UpTL each cause a long-term loss of 30 acres of Emergent Bay Habitat, while OcnP caused a long-term loss of 72 acres. Since these are all in the 1-to-100-acre range, these three options received a partial score of –1. OBC affected 0 acres of Emergent Bay Habitat, leading to a partial score of 0. No piping plover sites are impacted by any option, leading to partial scores on 0. Averages of the partial scores for each option are presented in Table 2-31.

OBC and OBSC will allow temporary creation of Terrestrial Habitat for scores of +1. UpC will permanently remove 176 acres of Terrestrial Habitat from customary usage for a –2, whereas, UpTL should improve 172 acres (see Section 2.9.3.2) for a +2. OcnP would cause the loss of 15 acres of Terrestrial Habitat for a score of –1.

All Water Column scores are 0 since, while there is turbidity associated with OBUn, the seagrass model showed no long-term difference between the with- and without-placement scenarios, and the sediment transport model showed a sharp decrease in the difference between the with- and without-placement turbidity within a few months. Therefore, the fact that some other options reduce that turbidity is not a quantifiable benefit.

For impacts to Human Uses, all of the options produce minimal to no TSS, according to the models, and there are no impacts to coastal cabins, so the only scoring comes from the long-term aesthetic impact of 176 acres of Upland Confined placement areas to a height of 33'. Therefore, for UpC, a partial score of 0, for no TSS averaged with a partial score of 0 for the loss of no coastal cabins, and –1 for LTA impacts, leads to a final score of –0.3. OBC, OBSC, UpTL, and OcnP generate no TSS, impact no coastal cabins, and have no LTA impacts, leading to final scores of 0.0.

2.10.6 Reach 6

The discussion in this section is based on the scoring criteria presented above in Section 2.8.2. The results of the Matrix are summarized in Table 2-32.

2.10.6.1 Dredging Action

The Dredging Action column is based on the acres of the receptors, except for Water Column Effects and Human Uses. Since all dredging occurs in the GIWW, no acres of any receptor are impacted and therefore, the score for all options is 0. For Water Column Impacts, the turbidity and toxicity effects, if there are any, would be the same for all options during the dredging phase, and all scores are 0. Human Use impacts are based on the number of dredging/construction days, which is 588 for the present practice, OBUn. For OBC (971 days or 383 > OBUn) and OBSC (882 days or 294 > OBUn), the number of days is within the range of 101 to 500 greater than OBUn, leading to scores of –1. For UpC and UpTL (both 1,416 days or 828 > OBUn), the number of days is within the range of 501 to 1,000 greater than OBUn, leading to scores of –2. OcnP (2,353 days) requires 1,765 days more than OBUn, leading to a score of –3.

2.10.6.2 Conveyance Action

The Conveyance Action column is also based on the acres of the receptors, except for Water Column Effects and Human Uses. For all of the acre receptors, there are impacts from laying pipelines and dredging booster channels, which fall into the 1 – 100 range (with one exception), leading to score of –1 for UpC, UpTL, and OcnP, for one or more receptors. The exception is that OcnP impacts 124 more acres of seagrass than does OBUn, leading to a score of –2. There are no water column effects from the other options, relative to the present practice, OBUn, except for those associated with the booster channel dredging for UpC, UpTL, and OcnP, which leads to a score of –1 for these three options. For Human Uses, all options have more pmds than OBUn in the range of 2,501 – 10,000, for OBC, OBSC, UpC and UpTL, generating scores of –2, and >10,000 for OcnP, leading to a score of –3.

Table 2-32

Matrix Summary for Reach 6

Receptor	Option	Dredging Impact	Dredging Score	Conveyance Impact	Conveyance Score	Placement Impact	Placement Score	Post-placement Impact	Post-placement Score	Total
Seagrass	OBUn	0 ac	0.0	0 ac	0.0	596 ac	0.0	149 Long term ac 176 20% isopleth ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	420 ac	2.0	420 Permanent ac 0 20% isopleth ac	0.0	**2.0**
	OBSC	0 ac	0.0	0 ac	0.0	456 ac	2.0	456 Permanent ac 0 20% isopleth ac	0.0	**2.0**
	UpC	0 ac	0.0	38 ac	-1.0	0 ac	2.0	38 Long term ac 0 20% isopleth ac	2.0	**3.0**
	UpTL	0 ac	0.0	38 ac	-1.0	0 ac	2.0	38 Long term ac 0 20% isopleth ac	2.0	**3.0**
	OcnP	0 ac	0.0	124 ac	-2.0	0 ac	2.0	124 Long term ac 0 20% isopleth ac	1.5	**1.5**
Open-Bay Bottom	OBUn	0 ac	0.0	0 ac	0.0	895 ac	0.0	0 * ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	630 ac	2.0	630 Permanent ac	-2.0	**0.0**
	OBSC	0 ac	0.0	0 ac	0.0	685 ac	2.0	685 Permanent ac	-2.0	**0.0**
	UpC	0 ac	0.0	42 ac	-1.0	0 ac	2.0	42 Long term ac	-1.0	**0.0**
	UpTL	0 ac	0.0	42 ac	-1.0	0 ac	2.0	42 Long term ac	-1.0	**0.0**
	OcnP	0 ac	0.0	10 ac	-1.0	0 ac	2.0	10 Long term ac	-1.0	**0.0**
* Benthos recover rapidly except very near PA										
Emergent Bay Habitat	OBUn	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac, 0 PP**	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac, 0 PP	0.0	**0.0**
	OBSC	0 ac	0.0	0 ac	0.0	0 ac	0.0	Temp creation, 0 PP	0.5	**0.5**
	UpC	0 ac	0.0	4 ac	-1.0	0 ac	0.0	4 Long term ac, 0 PP	-0.5	**-1.5**
	UpTL	0 ac	0.0	4 ac	-1.0	0 ac	0.0	4 Long term ac, 0 PP	-0.5	**-1.5**
	OcnP	0 ac	0.0	7 ac	-1.0	0 ac	0.0	7 ac, 0 PP	-0.5	**-1.5**
** Piping Plover Sites										
Terrestrial Habitat	OBUn	0 ac	0.0	0 ac	0.0	0 ac	0.0	0 ac	0.0	**0.0**
	OBC	0 ac	0.0	0 ac	0.0	0 ac	0.0	Temp creation	1.0	**1.0**
	OBSC	0 ac	0.0	0 ac	0.0	0 ac	0.0	Temp creation	1.0	**1.0**
	UpC	0 ac	0.0	28 ac	-1.0	716 ac	-2.0	716 Permanent ac	-2.0	**-5.0**
	UpTL	0 ac	0.0	28 ac	-1.0	745 ac	-2.0	745 Improvement ac	2.0	**-1.0**
	OcnP	0 ac	0.0	24 ac	-1.0	0 ac	0.0	24 Long term ac	-1.0	**-2.0**
Water Column Effect	OBUn	0 ac	0.0	booster chann	0.0	ty, no volur	0.0	No long-term turbidity	0.0	**0.0**
	OBC	0 ac	0.0	booster chann	0.0	No	0.0	Reduce turbidity	0.0	**0.0**
	OBSC	0 ac	0.0	booster chann	0.0	Turbidity,	-0.5	No long-term turbidity	0.0	**-0.5**
	UpC	0 ac	0.0	;ooster channe	-1.0	No	0.5	Reduce turbidity	0.0	**-0.5**
	UpTL	0 ac	0.0	;ooster channe	-1.0	No	0.5	Reduce turbidity	0.0	**-0.5**
	OcnP	0 ac	0.0	;ooster channe	-1.0	Transfer turbidity,	0.0	Reduce turbidity	0.0	**-1.0**
Human Uses	OBUn	588 days	0.0	588 pmd[a]	0.0	0 ac	0.0	Minimal TSS, 0 CC[b], no LTA[c]	0.0	**0.0**
	OBC	971 days	-1.0	6,794 pmd	-2.0	1,050 ac	-3.0	No TSS, 0 CC, no LTA	0.0	**-6.0**
	OBSC	882 days	-1.0	6,176 pmd	-2.0	1,141 ac	-3.0	Minimal TSS, 0 CC, no LTA	0.0	**-6.0**
	UpC	1,416 days	-2.0	9,915 pmd	-2.0	716 ac	-2.0	No TSS, 0 CC, LTA	-0.3	**-6.3**
	UpTL	1,416 days	-2.0	9,915 pmd	-2.0	745 ac	-2.0	No TSS, 0 CC, no LTA	0.0	**-6.0**
	OcnP	2,353 days	-3.0	68,235 pmd	-3.0	0 ac	0.0	No TSS, 0 CC, no LTA	0.0	**-6.0**

[a] pipeline-mile-days; [b] Coastal Cabins; [c] Long-term aesthetic effect

2.10.6.3 Placement Action

The Placement Action column is also based on the acres of the receptors, except for Water Column Effects and Human Uses. The guidance given in Section 2.8.2 and the fact that all options impact the same or fewer acres than does OBUn, lead to neutral or positive scores for Seagrass, Open-Bay Bottom, and Emergent Bay Habitats. UpC and UpTL impact 716 and 745 more acres of Terrestrial Habitat, respectively, than does OBUn, leading to scores of –2.

As noted in Section 2.8.2, no scores were based on toxicants in the elutriate because there was no evidence of problems since 1986. Therefore, only the reduction in turbidity, associated with OBC, UpC, and UpTL and the loss of water volume for plankton and nekton, associated with the creation of OBC and OBSC placement areas, led to Water Quality scoring. There is some turbidity associated with OBUn, so the reduction of turbidity for UpC and UpTL led to partial scores of +1, while these options lead to no volume loss, for a partial score of 0, and an average score of +0.5. OBC, which reduced turbidity (partial score of +1) but caused a volume loss for aquatic flora and fauna (partial score of –1), received an average score of 0, while OBSC, which caused the volume loss but did not reduce turbidity completely, received an average score of –0.5. OcnP, which only transferred the turbidity from the Laguna to the Gulf of Mexico but caused no volume loss, received an average score of 0.

Scores for Human Uses were determined by the number of acres removed from existing uses by placement. The existing placement areas have been designated for OBUn, so OBUn removes 0 acres from existing practice. OBC and OBSC remove 1,050 and 1,141 acres of the Laguna Madre, respectively, from existing uses of fishing, boating, etc., leading to scores of –3 for being in the >1,000 acre category. UpC and UpTL removed 716 and 745 acres of Terrestrial Habitat from customary use, respectively, which put them in the 100 – 1,000 acre category, and both received a score of –2. OcnP removed 0 acres from existing uses and received a score of 0.

2.10.6.4 Post-Placement Action

The Post-Placement Action is a little more complicated because, as can be seen from Table 2-32, there are more types of impacts per receptor than for the other actions. For example, there is burial of 596 acres of seagrass by OBUn, but there is empirical evidence (Sheridan, 1999) that recovery occurs over 75 percent of this area between dredging cycles, so 25 percent of this is considered a long-term loss. OBC and OBSC, on the other hand, lead to permanent loss of seagrasses of 420 and 456 acres of seagrass, respectively, leading to partial scores of –2. However, the computer models showed 176 acres between the isopleths for 20 percent irradiance reaching the seagrasses, with and without OBUn. It was assumed that there would be no acreage differences between isopleths for the other options, so OBC and OBSC received partial scores of +2, based on the acreage between the isopleths. The average of partial scores of –2 and +2 is 0. Therefore, OBC and OBSC received final scores of 0.

The acres of seagrass lost to the booster pump channels for UpC and UpTL is less than the long-term acreage for OBUn, and is also long-term loss and probably permanent. Therefore, there is a gain in the 101 – 1,000 acre scoring range, leading to partial scores of +2 when UpC and UpTL are compared with OBUn. Averaged with the +2, based on the acreage between the isopleths, leads to final scores of +2, for these two options. The acres of seagrass lost to the booster pump channels for OcnP is less than the long-term acreage for OBUn, leading to a gain in the 1-to-100-acre scoring range, for a partial score of +1, when OcnP is compared with OBUn. Averaged with the +2, based on the acreage between the isopleths, leads to a final score of +1.5 for the OcnP option.

Research has shown that benthos recover rapidly, except in the immediate vicinity of the placement area (Sheridan, 1999). Therefore, the area of impact for post-placement for OBUn is not enough to change the permanent or long-term impacts of the other options and, therefore, OBC and OBSC received scores of –2, while UpC, UpTL, and OcnP received scores of –1.

OBSC will allow temporary creation of Emergent Bay Habitat from Seagrass and Open-Bay Bottom and received a partial score of +1. UpC and UpTL each cause a long-term loss of 4 acres of Emergent Bay Habitat, while OcnP caused a long-term loss of 7 acres. Since these are all in the 1-to-100-acre range, these three options received a partial score of –1. OBC affected 0 acres of Emergent Bay Habitat, leading to a partial score of 0. No piping plover sites are impacted by any option, leading to partial scores on 0. Averages of the partial scores for each option are presented in Table 2-32.

OBC and OBSC will allow temporary creation of Terrestrial Habitat for scores of +1. UpC will permanently remove 716 acres of Terrestrial Habitat from customary usage for a –2, whereas UpTL should improve 745 acres (see Section 2.9.3.2) for a +2. OcnP would cause the loss of 24 acres of Terrestrial Habitat for a score of –1.

All Water Column scores are 0 since, while there is turbidity associated with OBUn, the seagrass model showed no long-term difference between the with- and without-placement scenarios, and the sediment transport model showed a sharp decrease in the difference between the with- and without-placement turbidity within a few months. Therefore, the fact that some other options reduce that turbidity is not a quantifiable benefit.

For impacts to Human Uses, all of the options produce minimal to no TSS, according to the models, and there are no impacts to coastal cabins, so the only scoring comes from the long-term aesthetic impact of 716 acres of Upland Confined placement areas to a height of 31 feet. Therefore, for UpC, a partial score of 0, for no TSS, averaged with a partial score of 0, for the loss of no coastal cabins, and –1 for LTA impacts, leads to a final score of –0.3. OBC, OBSC, UpTL, and OcnP generate no TSS, impact no coastal cabins, and have no LTA impacts, leading to final scores of 0.0.

2.10.7 Discussion and Summary

NEPA requires that impacts to the human environment be addressed by an EA or an EIS. Human Environment "shall be interpreted comprehensively to include the natural and physical environment and the relationship of people to that environment" (40 CFR 1508.14). The method used here to arrive at the preferred placement alternative, by reach, was developed with the help of the ICT to allow for a systematic, objective approach to selection. It is an approach that balanced the impacts to the various components of the human environment and could be applied without knowledge of the ultimate outcome of the analysis.

An examination of Tables 2-27 through 2-32 indicates that if the scores were summed by alternative, the present practices, Open-Bay Unconfined Placement in Reaches 1, 2, 4, 5, and 6 and Upland Confined Placement in Reach 3, are the preferred alternatives. For Reach 3, the selection is intuitively obvious; i.e., upland placement areas exist and have been used for years, ocean placement is not feasible, and open-bay options would require covering seagrasses and algal/sand flats in The Hole, the closest open-bay habitat. Additionally, Impacts to Human Uses in Reach 3, clearly favor Upland Placement due to the large number of days for dredging and construction, with concomitant interference with fishing and boating; the large increase in pmd, with concomitant interference with human uses and increased risk to human safety; and the long-term losses to The Hole.

For Reaches 1, 2, and 4, Open-Bay Unconfined appears the preferred alternative, driven largely by impacts to Human Uses. The interference with human uses of the Laguna Madre, plus the safety issues associated with the large increase in dredging/construction days and pmd, and the removal of large acreages from existing uses, combine to increase impacts from the placement alternatives compared with present practice. Additionally, the loss of coastal cabins in these reaches, especially the loss of 33 cabins in Reach 2, and the loss of known piping plover usage sites in Reach 2, added to the negative scores for some options.

For Reach 5, Open-Bay Confined and Open-Bay Semiconfined both had scores of –1.0, so Open-Bay Unconfined was not as preferable as with Reaches 1, 2, and 4. This was in part due to fewer impacts to seagrasses and Human Uses than in Reaches 1–4. The favorable scores for these items were due to the fact that the amount of maintenance material from Reach 5 is relatively small and, therefore, placement areas are small.

For Reach 6, there are significant impacts to Human Uses because of increases in dredging/construction days and pmd associated with larger placement areas and longer pipelines for ocean placement to avoid the City of South Padre Island. Benefits to seagrass for all options in Reach 6 were more dramatic than for Reach 5, primarily due to the number of acres between the 20 percent light irradiance isopleths, with and without Open-Bay Unconfined placement. However, the benefits to seagrass did not completely offset the increased impacts to Human Uses, and Open-Bay Confined and Open-Bay Semiconfined placement both received scores of –3.

Originally, the scores for the various receptors were to be summed by alternatives to yield an overall composite score by alternative. As can be seen, from an examination of Table 2-27, for example, this would lead to composite scores for Reach 1 from 0.0 for the present practice (OBUn) to –12.3 (UpC). However, Human Uses dominated most reaches and the ICT recommended, after much discussion, that there is too much "apples to oranges" comparison in this approach and that, without weighting factors, a summing approach could not be used. However, before coming to an agreement on weighting factors, the ICT determined that it would be necessary to include a management plan for each PA separately in the DMMP. Therefore, the ICT recommended building on the information developed during the matrix analysis and examine the data developed in smaller units. For some areas, several PAs could be grouped together, whereas in other areas, the analysis would have to focus down to individual PAs. Even where several PAs could be grouped, the ICT recommended that the final DMMP be developed so that each PA and its management plan were described individually. This was deemed advantageous since past dredging contracts were let that covered different, sometimes widely separated, portions of the Laguna Madre, and the PAs that were grouped for analysis might not all be dredged at the same time.

2.11 DREDGED MATERIAL MANAGEMENT PLAN

The DMMP as described below is the recommended plan for the project. The USACE worked closely with the agencies in the ICT to develop this plan after considering impacts to the entire ecosystem of the Laguna Madre.

As noted above, the ICT came to believe that the best DMMP would be one that examined each PA, individually. Therefore, in a series of meetings, a DMMP was developed which is included in full in Appendix A, and is summarized here. For each PA in each reach, available information on frequency of use, quantity of dredged material placed on the PA per dredging cycle, size of the PA, and grain size was generated from historical USACE records from May 1949 through March 1995 (Table 2-33). Information on seagrass coverage was obtained from current information and the locations of PAs were more accurately determined and superimposed on the 1995–1996 Digital Orthographic Quarter-Quads (DOQQs) and made available to the ICT, via printed copies and computer-aided projection on a screen, so that the ICT members could examine each particular area, as needed. Also included in Table 2-33 is information on the expected useful life of fully confined PAs included in the DMMP.

The ICT considered several alternative methods for dredging and placement of shoaled material in the GIWW to identify the least environmentally damaging alternative that was within the engineering capabilities of the USACE and was economically feasible. The ICT reached consensus on the DMMP. The placement areas for the DMMP are depicted in Figure 1-2a through f.

The PAs will be managed primarily for reducing impacts to nearby seagrass habitat, but some sites will be managed for bird use, vegetation control, or public recreation use. All discussions on management of the PAs in Reach 1 and some of the PAs in Reach 2 include the recommendations of Dr. Allan Chaney and Mr. Gene Blacklock based on the latest bird use information and management strategies needed to enhance the sites for birds. Special concerns on management practices, as contained in the PINS management plan (Draft included as Appendix C), of the PAs located inside the Congressionally authorized boundaries of PINS have been addressed as well. The Permanent School Fund's minerals in the project area can and will be developed, and the dredging and disposal of dredged materials from the GIWW in the Laguna Madre will not put an added burden on minerals development.

In some cases, the ICT recommended it would best facilitate dredged material management in a PA if the designated boundaries were shifted to include all of an island or nearby deep, unvegetated water. All islands inside the PAs were created during GIWW construction and nourished with

TABLE 2-33

HISTORICAL MAINTENANCE MATERIAL INFORMATION

Reach	Segment	PA	Average % Sand	# Uses (1948-1995)	Frequency of Use (1948-1995) (yrs)	Size of Designated PA (ac)	Per Cycle Discharge (CY)	Annual Discharge (CY)	Approximate Useful Life* (Years)
1	1	175	N/D	0	N/A	29.1	N/A	N/A	N/A
		176	50.10	1	46.4	133.8	128,041	2,760	813
		177	72.20	1	46.4	35.8	74,691	1,610	N/A
		178	N/D	2	23.2	125.3	100,408	4,328	N/A
		179	68.20	2	23.2	40.1	30,940	1,334	N/A
		180	N/D	5	9.28	125.6	122,564	13,207	N/A
		181	36.28	6	7.73	96.6	73,253	9,472	N/A
	2	182	4.22	3	15.5	58.5	61,126	3,952	N/A
		183	79.90	3	15.5	152.1	115,008	7,436	N/A
		184	7.35	4	11.6	98.7	84,640	7,297	N/A
		185	58.20	6	7.73	105.4	104,431	13,504	N/A
		186	33.73	10	4.64	117.4	126,495	27,262	N/A
	3	187	24.02	13	3.57	137.8	183,893	51,522	N/A
		188	27.14	14	3.31	165.8	196,804	59,380	N/A
		189	N/D	14	3.31	124.7	157,432	47,501	N/A
		190	20.85	11	4.22	69.9	114,168	27,066	N/A
		191	4.90	8	5.80	57.3	95,129	16,402	N/A
2	4	192	33.40	9	5.16	90.6	80,009	15,519	N/A
		193	N/D	9	5.16	90.6	87,218	16,917	N/A
		194	55.21	12	3.87	121.5	92,550	23,935	N/A
		195	85.00	10	4.64	103.0	112,778	24,306	N/A
		196	50.56	7	6.63	103.0	102,946	15,531	97
	5	197	25.40	15	3.09	304.4	318,930	103,102	N/A
		198	34.40	18	2.58	146.2	132,755	51,500	N/A
		199	11.87	16	2.90	124.9	140,854	48,570	N/A
		200	27.00	15	3.09	196.2	156,537	50,605	N/A
		201	18.32	14	3.31	173.7	177,145	53,449	N/A
		202	7.58	16	2.90	195.6	195,382	67,373	83
3	6	203	27.08	6	7.73	324.5	149,376	19,316	137
		204	71.50	5	9.28	167.7	100,581	10,838	389
	7	206	N/D	5	9.28	380.4	352,592	37,995	120
		207	N/D	5	9.28	322.2	524,366	56,505	123/257**
	8	208	75.30	9	5.16	769.0	715,043	138,694	86/67**
	9	209	N/D	6	7.73	193.4	110,338	14,268	N/A
		210	N/D	13	3.57	242.8	81,911	22,949	N/A
4	10	211	30.44	15	3.09	140.8	117,247	37,903	N/A
		212	28.17	15	3.09	192.1	175,985	56,892	N/A
		213	16.06	14	3.31	191.7	101,885	30,741	N/A
	11	214	17.54	9	5.16	191.4	216,337	41,962	N/A
		215	7.41	11	4.22	194.1	193,123	45,783	N/A
		216	12.17	6	7.73	194.7	149,645	19,351	N/A
		217	22.90	8	5.80	193.3	181,505	31,294	N/A
	12	218	18.75	12	3.87	194.3	218,230	56,439	N/A
		219	13.14	10	4.64	119.8	112,608	24,269	N/A
		220	8.05	10	4.64	216.1	153,758	33,138	N/A
	13	221	8.35	17	2.73 **	387.2	177,214	64,928	N/A
		222	23.18	10	4.64	259.4	183,776	39,607	132
5	14	223	56.00	6	7.73	158.8	92,078	11,907	254
		224	35.17	3	15.5	175.4	58,422	3,777	909
		225	14.70	1	46.4	84.3	83,936	1,809	1,362
		226	N/D	13	3.57	257.6	84,497	23,674	400
	15	227	22.99	5	9.28	65.4	91,128	9,820	N/A
		228	16.48	5	9.28	294.4	122,115	13,159	600/479**
6	16	229	6.71	3	15.5	129.2	27,740	1,794	N/A
		230	N/D	1	46.4	82.5	43,260	932	N/A

TABLE 2-33 (Concluded)

HISTORICAL MAINTENANCE MATERIAL INFORMATION

Reach	Segment	PA	Average % Sand	# Uses (1948-1995)	Frequency of Use (1948-1995) (yrs)	Size of Designated PA (ac)	Per Cycle Discharge (CY)	Annual Discharge (CY)	Approximate Useful Life* (Years)
		231	N/D	1	46.4	127.8	69,982	1,508	N/A
		232	16.89	12	3.87	127.4	57,126	14,744	N/A
	17	233	8.01	24	1.93	210.0	392,773	203,158	N/A
		234	12.62	25	1.86	121.6	227,513	122,582	N/A
		235	30.46	5	9.28	121.6	43,053	4,639	N/A
		236	N/D	N/D	N/D	129.1	N/D	N/D	N/A
	18	239	53.99	6	7.73	49.4	86,056	11,128	N/A
		240	39.30	5	9.28	N/D	97,482	10,505	N/A

* This is the expected useful life for these confined PAs, based on caluclations made with models developed by the USACE Waterways Experiment Station, known grain size characteristics, and an ultimate levee height of 20' for PAs 176 - 208 and 25' for PAs 222 - 228S. This calculation is only applicable to fully-confined sites are other sites are not included in this column.

** These PAs contain two separate confined areas, north and south. The expected usefule life of the north area is listed first.

*** Historic use of Pa 221 has varied from higher use (the frequency presented above) in the northern one-fourth to less frequent use (6 - 7 years) in the southern three-fourths.

shoaled material during subsequent maintenance dredging operations. The ICT also recommended that new PAs were needed or existing PAs should be combined to meet special management requirements or to handle excess dredged material if it is determined an existing PA cannot accommodate all the material normally designated for the site and meet the goals of the management plan. If any of the new PAs are located outside of the existing disposal easements, the USACE will use the submerged sites pursuant to the Navigation Servitude Authority. However, PAs 178 through 235 in the preferred alternative (DMMP) all fall within navigable waters of the United States or are on top of islands created by direct deposit of dredged material, which thereby remain subject to the navigation servitude under the Commerce Clause of the United States Constitution (there are no changes to PAs 236, 239, or 240). This power grants the United States the prior right to use the bed and banks of navigable waters for the purposes of navigation without payment of just compensation to the owner, even if the owner is still the State of Texas or a subsequent patentee. Along the entire alignment of the GIWW between Corpus Christi and the Mexican border, the United States, on August 21, 1947, was granted a perpetual 900-foot-wide channel right-of-way easement to state-owned land to cut the initial channel as well as a perpetual easement for the placement of dredged material along a strip, 5,000 feet wide along the east side of the right of way strip just described. While the vast majority of the easement was unnecessary due to the powers of the United States under the navigation servitude, the easement would come into play on fast lands (naturally occurring) not subject to the servitude. Therefore, all existing areas and all proposed expansions of placement areas on the east side of the existing GIWW are covered both by the navigation servitude and/or the 1947 perpetual dredged material disposal easement. All new or expanded placement areas on the west side of the existing GIWW are covered by the navigation servitude. Therefore no acquisition of real estate interests is required for any of the placement areas proposed along the GIWW in the Laguna Madre.

Another concern of the ICT is the issue of coastal cabins located inside the PAs in the upper Laguna Madre. Many of these cabins, which have GLO permits, could be damaged if the entire PA is used for disposal. At their discretion, GLO/State Land Board will require cabins to be relocated or removed, as necessary, prior to placement of dredged material.

The management plans in the DMMP will be reviewed prior to each dredging event to ensure the best management practice for each PA in every reach is incorporated to the extent practicable. It is assumed that all pumping of dredged material will be done by the best management practices, including the use of a dispersing or energy-dissipating device to reduce the erosive force of water exiting the pipe and frequent movement of the pipe so that the material is spread out in a thin layer to decrease the chances of excessive burial of seagrass and creating a scour hole at discharge.

To minimize impacts to seagrass, the ICT recommended that the management plan observe the restriction of confining open-bay, unconfined placement of maintenance material to the period from November to February, inclusive, throughout the Laguna Madre. Dunton et al. (2003) have noted that this is the period when seagrass is dormant and will be impacted least by turbidity. Hydrodynamic and Sediment Transport modeling also indicated that the worst-case scenario of the impact from high turbidity levels (reducing light penetration to the seagrass below 20 percent of surface irradiance) is usually confined to an area within ¾ to 1 mile of the open-water discharge point and such high turbidity conditions attributable to unconfined disposal generally occur over a period of less than 3 months after disposal is completed. Another impact of dredged material disposal is seagrass burial when the mud flows away from the point of discharge. Additional studies have shown that if seagrass is buried under no more than 3 inches of sediment, it can fully recover in about 3–5 years. However, in the case of shoalgrass, the dominant seagrass in most of the Laguna Madre, studies also have shown that new shoalgrass quickly invades the buried site through seed dispersal to create new seagrass meadows before the original plants have a chance to regenerate. Therefore, if dredging and disposal operations are conducted during the dormant phase of seagrass growth, the plants are not affected as much as in other seasons, unless they are buried. Even with burial close to the PA, shoalgrass can quickly recover through colonization by new plants or growth of the original plants if burial is less than 3 inches.

2.11.1 Reach 1

This Reach contains PAs 175 through 191. PAs 182, 183, 185, 187, 188, 190, and 191 are inside the Congressionally authorized PINS boundary.

The ICT considered all of the alternative dredging and placement options described earlier in this section of the FEIS for these PAs. Following the criteria designed to identify fatal flaws in a disposal option, the ICT recommended eliminating ocean placement as a viable option due to the long haul distances, lack of appropriate equipment, and excessive pumping distances for pipeline disposal. One other option, piping the material across Padre Island was eliminated in most of Reach 1 because the PINS could not permit it, since this action would represent an impairment of natural resources in the Park. Likewise, Upland Confined and Upland Thin Layer Placement were eliminated from further consideration because of the permanent impacts to seagrass and wetland habitats that could occur in installing the pipelines for pumping the material to an upland site. The required pumping distances also could require booster pumps, which would reduce efficiency. The only remaining options (fully confined, semiconfined, and unconfined open-bay placement) were analyzed for each PA in Reach 1 before determining the best option, given the unique combination of habitat, dredging frequency and volume, and environmental management plans proposed for each PA.

In addition to managing the PAs for seagrass, bird use, and recreational opportunities proposed by others (when compatible with the DMMP), the ICT reviewed the management plan prepared by the PINS for PAs located inside the Congressionally authorized PINS boundaries for compatibility with the DMMP. The disposal practices described in the PINS plans were incorporated into the DMMP to the extent practicable. Some of the limitations on disposal described in the PINS plan could not be incorporated due to the type of material and dredging frequency or volume, but the ICT recommended each PA management plan be reviewed prior to dredging and placement to determine the best plan for that dredging cycle in coordination with the PINS personnel.

In the past, placement of maintenance material in this reach was strictly open-bay placement. A number of techniques were proposed in the DMMP to reduce turbidity, reduce coverage of seagrass, and encourage bird use. Under the DMMP, only one PA includes no changes from present practice and it has never been used since dredging of the GIWW through the Laguna Madre. One PA will be fully leveed and four others are scheduled for partial levees or training levees to control flow of the dredged material. Material will be placed on the emergent islands, using diffusers, on fourteen of the PAs; care will be taken to avoid circulation channels at five; and material will be pumped to deeper water to avoid seagrass at one other PA. Five PAs are scheduled to take on a limited amount of material, with the excess pumped to nearby PAs; four are scheduled to be expanded for bird use or seagrass avoidance; and the impacts from two new PAs are included in Section 4.4.1.4 and 4.4.4. The following is a summary of the actions proposed in the DMMP by PA.

PA 175 – Continue with the current practice of not using this upland, unconfined PA, but it will remain as an authorized PA.

PA 176 – Complete the levee and use the site as an upland confined placement option. The FWS will be consulted before levee construction begins to ensure there are no adverse impacts to the piping plover.

PA 177 – Make complete levees on the east (back), north, and south sides, with a partial levee and baffles on the west side to retain as much material on the island as possible. This would partially contain the dredged material and prevent the material from flowing north, east, or south onto seagrass beds.

PA 178 – Protect the seagrasses to the east with a training levee. The circulation channels will be left open. The northern islands in the chain would be avoided unless needed in the future, but the PA would be expanded to the south to include the island immediately to the south. Its current and revised position and boundaries are documented in Figure 1-2a. The second island from the north is an important bird nesting island and will be avoided during disposal operations. Flow onto the emergent islands would be directed to the west, using natural contours as much as possible. The cabin owner may need to be notified that the cabin will be impacted by future disposal.

PA 179 – Expand the PA to include all of the islands and pump the maintenance material on top of the mounds to increase the size of these islands for bird use, while avoiding runoff onto the seagrasses to the extent possible. Its current and revised position and boundaries are documented in Figure 1-2a. A training levee will be placed on the south end of the PA to prevent maintenance material from filling a small boat channel. Six of the nine cabins inside the present and proposed boundaries may be affected.

PA 180 – Pump the maintenance material to the east side of the mounds with a diffuser at the end of the pipe to prevent scouring and direct the flow to the east to increase the size of these islands for bird use. This technique will help reduce runoff onto the seagrasses. Care will be taken to keep circulation channels open. Eleven cabins may be affected.

PA 180A – Incorporate the bird plan to nourish and rebuild two man-made islands on the west side of the GIWW opposite from PA 180 to establish a new PA (PA 180A) at this location and use some of the maintenance material to rebuild the islands on an "as needed" basis. Its current and revised position and boundaries are documented in Figure 1-2a. Because there will be new impacts to seagrass beds around the area, the USACE agreed to this plan only if the rest of the ICT concurs and there is no mitigation required for loss of seagrass. There is one cabin on one of these islands.

PA 181 – Pump the maintenance material on top or just east of the mounds to direct the flow to the east side to increase the size of these islands for bird use. This technique will help reduce runoff onto the seagrasses. Care will be taken to keep circulation channels open. Eight permitted cabins and one cabin used by TAMU for research may be affected.

PA 182 – Avoid the Fina Mitigation Area located east of the northern part of the PA and the trees on the northern one-third of the site. Trees and shrubs in the working area would be protected from moving equipment and dredge pipe. Placement of dredge material either on top or east of the island would protect or avoid trees and shrubs. The maintenance material would be pumped on top or to the east side of the mounds at the southern two-thirds of the PA to direct the flow to the east side to increase the size of these islands for bird use. A diffuser will be used on the end of the dredge pipe to minimize energy and prevent scouring on the mounds. This should help maximize disposal on the island and minimize runoff into the surrounding water and seagrasses. Extend the southern PA boundary to include all of the island. Its current and revised position and boundaries are documented in Figure 1-2a.

PA 182S – As part of the PINS management plan, the PINS proposed adding a new disposal site to the DMMP. The new site would enclose a small island located between PAs 182 and 183 that was probably created during construction of the GIWW. There is a pond on the island that PINS would like to protect during disposal operations. The ICT recommended that the new site be added to the DMMP. The new PA will be used for disposal during a dredging cycle for this reach of the GIWW when the need is determined by PINS and the ICT. Its current and revised position and boundaries are documented in Figure 1-2a.

PA 183 – Pump some of the maintenance material over the top and to the east side of the mounds at the south end of the PA to manipulate vegetative cover and enlarge the islands to the east for bird use. It may also be desirable to pump some material to the east side of the other islands, but the timing and need for this will be determined during coordination with the ICT and PINS. Material that cannot be utilized in PA183 will be pumped to PA184. The amount of material to be used at this site will be determined during preparation of disposal plans for each dredging cycle and in coordination with the ICT and PINS.

PA 184 – Pump the maintenance material over the crest to the west side of the islands to avoid coastal cabins, if possible, and avoid runoff onto seagrasses adjacent to the islands. However, avoidance of the coastal cabins may not be possible. Sixteen cabins inside the PA and 9 cabins outside the PA may be affected by this management plan. Emmord's Hole, located west of the PA, will be used only if the ICT concludes there is a compelling need for it. A complete discussion of Emmord's Hole is included as Section 2.11.7.

PA 185 – Place some (if not all) of the maintenance material on the east side of the lower two islands to build up the beach. Care must be taken to avoid filling in the wide channel between the northern island and South Bird Island northeast of the PA, as well as the small boat channel connecting Bird Island Basin to the GIWW. Material that cannot be utilized in PA185 will be pumped to PAs 184, 186, or Emmord's Hole. Extend the southern boundary of the PA to include all of the southernmost island to increase the size of the disposal area. Its current and revised position and boundaries are documented in Figure 1-2a.

PA 186 – Extend the PA boundary to the west to include deep water in Emmord's Hole and pump the maintenance material to the deeper water west of the PA to avoid seagrass. This also would avoid the cabins on the island in the northern portion of the PA. Its current and revised position and boundaries are documented in Figure 1-2a.

PA 187 – Pump some of the maintenance material on top of the emergent mounds on the south side of the north island and the north side of the south island to increase their size and enhance them for bird nesting. Dredged material will not be placed on the ridge along the middle of the PA to avoid the seagrasses and prevent the islands from coalescing. The ICT recommended that excess material be put in Emmord's Hole only if there is no other option available.

PA 188 – Pump maintenance material on top of the emergent mounds on the island in the north portion of the ridge to increase the size of the island for bird use. Emmord's Hole would be used as an alternate site for excess material from this PA only if there is no other option available. Its current and revised position and boundaries are documented in Figure 1-2a.

PA 189 – Follow the bird management plan and try to reestablish the southern island with dredged material for bird use. Because the material may not stack, the USACE will look into using a retaining system (sheetpile, geotubes, levees, etc.) to help retain material at the site. Extend the western boundary of PA 189 about 1,000 feet west at the north end and taper this new boundary back to the southwest corner of the PA, forming a triangular extension into deeper water to the west. Its current and revised position and boundaries are documented in Figure 1-2a. The new area will allow the USACE to place the dredge pipe over the ridge and pump excess material to the west in deeper, unvegetated water. A diffuser will be used on the end of the pipe to prevent scour. There are two cabins that may be impacted.

PA 190 – Pump the maintenance material on top of the islands at each end of the ridge to increase their size to about 1,200 feet in diameter for bird use. The ICT recommended that the 4 to 5 year interval between disposal operations, which was recommended in the PINS management plan, would be accommodated in the DMMP to the extent practicable. PA 189 could be an alternate site for some of the excess material.

PA 191 – Pump the maintenance material to the southeast side of Pelican Island in an existing small embayment to expand the southern end of the island. The intent is to expand the nesting area on the only nesting site for white pelicans in the Laguna Madre. When the island is at optimum size, future material can be pumped to PA 190 or PA 192. A training levee, which will be graded down after placement like all levees on PAs in the Congressionally authorized PINS boundary, will be placed on the southwest and south sides of Pelican Island to retain the material in the embayment and let excess material flow out on the southeast side to form a sloping beach.

2.11.2 Reach 2

This reach contains PAs 192 to 202. PAs 192, 194, and the northern half of PA 195 are also located inside the Congressionally authorized boundaries of PINS.

The ICT considered all of the alternative dredging and placement options described earlier in this section of the FEIS for the PAs in Reach 2. Following the criteria designed to identify fatal flaws in a disposal option, the ICT again recommended the elimination of ocean placement as a viable option due to the long haul distances, lack of appropriate equipment, and excessive pumping distances for pipeline disposal. One other option, piping the material across Padre Island was eliminated for Reach 2 because the PINS would not permit it, since this action would represent an impairment of natural resources in the Park. Likewise, Upland Confined and Upland Thin Layer Placement were eliminated from further consideration because of the permanent impacts to seagrass, serpulid reefs, and wetland habitats that would occur in pumping the material to an upland site. The required pumping distances also would require booster pumps, which would reduce efficiency. The only remaining options (fully confined, semiconfined, and unconfined open-bay placement) were analyzed for each PA in Reach 2 before determining the best option, given the unique combination of habitat, dredging frequency and volume, and environmental management plans proposed for each PA.

Because PAs 192, 194, and one-half of PA 195 are located inside the Congressionally authorized PINS boundary, the ICT reviewed the management plan prepared by the PINS for these PAs to determine compatibility with the DMMP. The disposal practices described in the PINS plans were incorporated into the DMMP to the extent practicable. Some of the limitations on disposal described in the PINS plan could not be incorporated due to type of material and dredging frequency or volume, but the ICT recommended that each PA management plan would be reviewed prior to dredging and placement to determine the best plan for that dredging cycle in coordination with the PINS personnel.

In the past, placement of maintenance material in this reach was strictly open-bay placement. Under the DMMP, three PAs include no changes from present practice, since dredged material at these PAs is presently placed in deep water containing no seagrass. One PA will be fully leveed and five others are scheduled for partial levees or training levees to control flow of the dredged material. Material will be placed on the emergent islands, using diffusers, on seven of the PAs; care will be taken to avoid circulation channels at five; and material will be pumped to deeper water to avoid seagrass at two other PAs. Five PAs are scheduled to take on a limited amount of material, with the excess pumped to nearby PAs; and five are scheduled to be expanded for bird use or seagrass avoidance. The impacts from the PA expansions are included in Section 4. The following is a summary of the actions proposed in the DMMP by PA.

PA 192 – Pump the maintenance material on top of the emergent thin mounds and the shallow areas, with frequent moving of the discharge pipe to stay on top of the string to increase the size of these islands for bird use, while minimizing impacts to seagrass.

PA 193 – Pump most of the maintenance material to the southeast side of the north island, gradually increasing the size of the island to the south, with the flow directed to the south. The north, west, and south boundaries of the PA will be moved out to include all of the islands for disposal use. Its current and revised position and boundaries are documented in Figure 1-2b.

PA 194 – Pump the maintenance material on top of the island to increase the size of the island for bird use and use training levees to help retain the material and prevent additional shoaling of the surrounding shallow areas and minimize impacts to surrounding seagrass. An existing small pond will be recreated after disposal is compete if it has filled in with sediments.

PA 195 – Extend the boundary of the PA south to include the four islands, an oil company access channel, and east to include the turning basin since the intent is to fill the channel with dredged material. Its current and revised position and boundaries are documented in Figure 1-2b. The maintenance material will be pumped on top of the islands and the flow directed to the south to increase the size of the islands for bird use, while minimizing impacts to seagrass. Two cabins may be impacted. The long-term effects of filling in the shallow area east of the PA must be determined since it may become piping plover critical habitat as it becomes emergent.

PA 196 – Confine the material on the island inside PA 196. To minimize short-term impacts to most of the cabins, use confining levees on the north, east, and south sides to hold material on that side and prevent seagrass burial there. Low training levees will be placed on the west side to hold most of the material flowing between the mounds on the island and build up the island. The cabin owners will be notified that they either need to raise their cabins or move them off the island. Over time the confining levees will be extended until the entire island is completely confined. Its current and revised position and boundaries are documented in Figure 1-2b.

PA 197 – Establish at least three corridors over the northern islands and pump some of the dredged material over the mounds to build up the northern islands for bird use. By using each corridor in alternating cycles, each area would have a 6-year interval between disposal operations for the surrounding seagrass to recover. Most of the dredged material would need to be placed on the southernmost island during each dredging cycle to build it up for bird use. Much of the excess material will flow east into the deep, unvegetated water. Extend the east boundary about 500 feet to the east from the north end of the southern island to the south end to provide space to place the pipe and to include the potential footprint of the material flowing into the deep water. Its current and revised position and boundaries are documented in Figure 1-2b. Two cabins located on the southernmost island are in the process of renewing their permits.

PA 198 – Continue with the current practice of unconfined disposal in the PA in deep, unvegetated water.

PA 199 – Shift the PA south to avoid the seagrass habitat and connect it to PA 200. All disposal of dredged material must be in the deep water area. There is a small channel between PAs 199 and 200. Fill it in with dredged material when the two PAs are combined. Its current and revised position and boundaries are documented in Figure 1-2b.

PA 200 – Continue current practice of unconfined disposal of dredged material since there is no nearby seagrass habitat or bird use area to be impacted.

PA 201 – Continue the present practice of unconfined disposal, but limit the disposal to the middle submerged area of the PA to avoid the bird islands at each end of the PA.

PA 202 – Extend the levees of this emergent site south to the channel between PAs 202 and 203 and north along the emergent area as far as needed to confine all the dredged material over the next 50 years. The expansion may need to enclose some open water to provide enough capacity for the 50-year life of the DMMP. Its current and revised position and boundaries are documented in Figure 1-2b.

2.11.3 Reach 3

This reach includes PAs 203-210, all located at upland sites in the Land Cut. Although PA 205 receives no maintenance material from the GIWW, the ICT recommended that it be consulted before use due to the PAs proximity to the GIWW. Since it is not used for placement of maintenance material from the GIWW, it is not part of the DMMP.

The ICT considered all of the alternative dredging and placement options described earlier in this section of the FEIS for the PAs in Reach 3. Following the criteria designed to identify fatal flaws in a disposal option, the ICT again recommended eliminating ocean placement as a viable option due to the long haul distances, lack of appropriate equipment, excessive pumping distances for pipeline disposal, and the prohibition against crossing the PINS. Open-Bay Disposal was also eliminated because the closest open-bay site is The Hole, which is a shallow, vegetated area that is a popular fishing destination. The ICT did not recommend taking any of the material to The Hole because of the impacts to seagrass and productive bay bottom that would accrue. Similarly, the Beach and Washover Nourishment options were eliminated for this reach because of the lack of sufficient sites to hold all of the dredged material and the prohibition against crossing PINS property with a pipeline. Thin Layer Placement was eliminated because of the lack of sufficient sites to hold all of the dredged material and because it would not enhance the upland (sand/mud flat) habitat, which is a goal of this option. The only remaining option (Upland Confined Placement) was analyzed for each PA in Reach 3 before determining the best management plan, given the unique combination of habitat, dredging frequency and volume, and environmental management plans proposed for each PA. In some cases, the ICT recommended that it was not necessary to completely confine a PA in this reach, as described below.

In the past, placement of maintenance material in this reach was into upland PAs, all but two of which are at least partially confined and all but three of which have some portion of the PA enclosed in full levees. Under the DMMP, all use of the PAs will continue with present practice, except that in the unconfined areas, the discharge pipe will be moved frequently to deposit only a thin layer of material to reduce the chances of flow outside the PA boundaries. Three of the PA boundaries will be expanded to include existing levees.

PA 203 – The southern end of PA 203 is fully leveed and encompasses about 108 acres. However, the front levee (nearest to the GIWW) may be outside the designated boundary of the PA. Its current and revised position and boundaries are documented in Figure 1-2b. Move the dredge pipe frequently to deposit only a thin layer of dredged material in the unconfined portion of the PA until reaching the confined area and then place the rest in the leveed section.

PA 204 – Continue with the present disposal practice in this completely leveed PA. The front levee (nearest to the GIWW) may be outside the designated boundary of the PA. Its current and revised position and boundaries are documented in Figure 1-2c.

PA 206 – The northern third of this PA is fully confined. The southern end has some training levees. However, the front levee (nearest to the GIWW) may be outside the designated boundary of the PA. Its current and revised position and boundaries are documented in Figure 1-2c. Continue with the current disposal practice and maintain the training levees, if they still exist, in the southern end.

PA 207 – This PA is fully confined in the lower two-thirds of the site. Continue with the current placement practice but move the dredge pipe frequently to keep the dredged material runoff as thin as possible in the unleveed section.

PA 208 – This is a very long PA with short, leveed sections in the middle and southern end of the site. Continue the current disposal practice, but move the pipeline frequently to prevent excessive dredged material run-off at any one location in the unleveed sections. Keep the channels clear of any dredged material during disposal operations.

PA 209 – This is a short PA without levees. Same management plan as for PA 208.

PA 210 – This is a short PA with levees at the back and on the sides in the southern third of the site. The GIWW side is open. Continue the present disposal practice in the semiconfined area and move the dredge pipe frequently in the unleveed section.

2.11.4 Reach 4

This reach contains PAs 211–222. Because several of the sites are close to the mainland or an entrance channel, are located in deep, unvegetated water, or have special requirements for environmental management, each PA or group of PAs was considered separately when determining the best dredging option for the area.

In the past, placement of maintenance material in this reach was strictly open-bay placement. Under the DMMP, PAs 213–219 include no changes from present practice, since dredged material at these PAs is presently placed in deep water containing no seagrass. Three PAs will be expanded, one will be reduced in size to help predator control, one will be completely leveed, and three will have additional levees or baffle levees to control flow of the dredged material. One PA will be moved and include subsurface levees, and the impacts from this and the other expansions are included in Section 4. The following is a summary of the actions proposed in the DMMP by PA.

PA 211 and 212 – PA 211 has an earthen levee on the east side to prevent sediment flowing out into the seagrass on the backside of the site. PA 212 consists of a series of small islands paralleling the GIWW just south of PA 211. Move the existing earthen levees on PA 211 farther to the east and north, add baffle levees across the site to slow the sediment flow and allow more settling, and add earthen levees on the west side while leaving the south side open, thus creating a horseshoe-shaped disposal site. Its current and revised position and boundaries are documented in Figure 1-2d.

For PA 212, remove the northernmost island and pile this material along with maintenance material on the next island to the south, creating a larger water gap between PAs 211 and 212. The islands in PA 212 would not be leveed to contain the dredged material, but would be managed for bird nesting by alternately disposing on one island during a dredging cycle and then on another island in the next cycle.

PAs 213–219 – These PAs are located on the east side of the GIWW in water too deep to support seagrass. Continue the present practice of using unconfined disposal at these sites, since there would be no significant biological benefits to be gained by trying to create a fully confined or semiconfined PA system in this area.

PA 220 – This L-shaped disposal site contains an emergent island located at the bend of the site, but much of it is outside of the boundary of the PA and is eroding severely on the north side.

An ocean placement alternative was considered for PAs 220 and 221 due to their frequent use and proximity to a pass. A bucket dredge and scow would be used to collect shoaled material from the GIWW near Port Mansfield Channel and taken offshore to a designated ocean disposal site. This alternative would be considered for future dredging cycles, provided it could be done economically, equipment was available, and EPA provided the necessary clearance for ocean disposal of the dredged material under Section 102 of the Marine Protection, Research and Sanctuaries Act.

The recommended management plan for this site would place geotubes on the shallow shelf around the existing island on three sides, leaving the south end open. Dredged sandy material from the Port Mansfield Channel would be stockpiled on the north side of the site and used to fill the geotubes later. Silty material in the GIWW from future dredging cycles would be used to fill in the horseshoe-shaped site surrounding the bird island to enhance bird nesting habitat. This would also protect seagrass near the site from burial and high turbidity to the north. The open southern end could be closed with geotubes later, if it is determined there is more erosion occurring there than is currently believed to exist. This alternative would require expanding the boundary of PA 220 beyond what is described in the 1975 EIS. Its current and revised position and boundaries are documented in Figure 1-2d.

PA 221 – Move PA 221 to the east side of the GIWW. Its current and revised position and boundaries are documented in Figure 1-2d. The new site would be known as PA 221A, but a linear arrangement of low geotubes or a levee created with in situ material (both subsurface) may be needed between the GIWW and PA 221A to prevent dredged material from flowing back into the GIWW.

An alternative consideration by the ICT would be offshore disposal using a bucket dredge and scows as described for PA 220. A determination will be made before each dredging cycle which alternative would be used based on ecosystem benefits and habitat needs, equipment limitations, disposal restrictions, and economics.

PA 222 – Extend the levees to the south and move the west levee farther out (in some areas, a short distance out into the water) to increase the size of the enclosed PA. Its current and revised position and boundaries are documented in Figure 1-2e. Since PA 222 is surrounded by seagrass, this action will permanently remove a small area of seagrass on the western side of the PA, but the larger area of seagrass surrounding the PA would be protected from turbidity or future releases of dredged material in the nonleveed section of the PA. Increase the size of the gap between the large leveed island and the islands to the south (outside PA 222) by pulling in material at the gap to construct the south levee.

2.11.5 Reach 5

This is the shortest reach in the Laguna Madre and contains PAs 223 to 228.

The ICT considered all of the alternative dredging and placement options described earlier in this section of the FEIS for these PAs. Following the criteria designed to identify fatal flaws in a disposal option, the ICT recommended eliminating ocean placement as a viable option due to the long haul distances between Mansfield Pass and Brazos Santiago Pass, lack of appropriate equipment, and excessive pumping distances for pipeline disposal. One other option, piping the material across Padre Island was eliminated because of the distance involved and the unacceptable impacts to seagrass and extensive sand/mud flats between the GIWW and the barrier island. Likewise, Upland Confined and Upland Thin Layer Placement were eliminated from further consideration because of the permanent impacts to seagrass and wetland habitats that would occur in pumping the material to an upland site. Another factor affecting upland placement is that the LANWR owns the upland area on the mainland opposite PAs 224–234 and will not accept dredged material in the Refuge. The only remaining options (fully confined, semiconfined, and unconfined open-bay placement) were analyzed for each PA in Reach 5 before determining the best option, given the unique combination of habitat, dredging frequency and volume, and environmental management plans proposed for each PA.

In the past, placement of maintenance material in this reach was strictly open-bay placement. Under the DMMP, only two PAs include no changes from present practice, since one is almost never used and the other is fully leveed. All of the others will be expanded and fully leveed. The impacts from the expansion of the PAs are included in Section 4. The following is a summary of the actions proposed in the DMMP by PA.

PA 223 – Create a fully confined earthen levee at this PA to protect the seagrass beds in nearby shallow water. The islands are so narrow that the western levee will have to be placed a short distance out into the water to create a useable PA. This will permanently remove a small area of seagrass, but will benefit the large area behind the PA. The gap at the south end would be enlarged by pulling material from the narrow channel onto the island to create the south levee for the PA. Its current and revised position and boundaries are documented in Figure 1-2e.

PAs 224 and 225 –These PAs are partially leveed but open on the west side. Fully confine the two sites to form one long PA with two cells. The east boundary will be moved out to enclose the levees and all of the islands. Its current and revised position and boundaries are documented in Figure 1-2e. The USACE may still retain the original PA numbers for each site/cell.

PA 226 –This PA is fully confined by earthen levees. It is used to contain maintenance material dredged from both the Arroyo Colorado and the GIWW. This PA has the capacity to hold material from the GIWW segments normally designated for PAs 224, 225, 226, and 227, unless a severe storm strikes the area and causes excessive shoaling. At this time, it may become necessary to divert dredged material to the other PAs to avoid depleting capacity at this site. Use and manage as currently done by the USACE.

PA 227 – This PA is an unconfined site located opposite the GIWW from the Arroyo Colorado. There are no plans to use this PA, but the USACE reserves the right to use the site on an emergency basis. As part of the management plan, the USACE may also use the site if the island appears to be in danger of disappearing through erosion. Leave the disposal site as it is since there are no plans to use it at this time.

PA 228 – Create a fully confined earthen levee system on 6,000 feet of the longest chain of islands at the north end and place the west levee a short distance into the water to achieve a width of at least 700 feet. Another 5,000 feet of the island chain on the south end will also be fully leveed to provide sufficient capacity for the life of the DMMP. The west boundary of the PA will be moved out to fully enclose the island to provide more capacity for the enclosed PA. Its current and revised position and boundaries are documented in Figure 1-2e. Trade-off a permanent loss of a small area of seagrass habitat to protect the much larger area of surrounding seagrass habitat. The USACE will determine the proper size of the PAs to be fully leveed and the best location for the levees.

2.11.6 Reach 6

This reach includes PAs 229 on the north end through 240 on the south end. Disposal options were examined for each PA separately, because several of the sites are close to the mainland or an entrance channel, are located in deep unvegetated water, or have special requirements for environmental management. Upland disposal on the mainland was not an option for PAs 224 through 234 because the LANWR owns the uplands.

In the past, placement of maintenance material in this reach was strictly open-bay placement. Under the DMMP, only the two southernmost PAs include no changes from present practice, since one of these sites is mostly confined and the other is small, rarely used, and mostly unvegetated. All of the others will continue to use unconfined open-bay placement, but five will have limitations on timing to avoid seagrass and nesting-bird impacts and some will have limitations on volume. Additionally, two of the sites will be moved into deeper water to avoid seagrass impacts and resuspension, which leads to increased dredging frequency. Material will be placed on the emergent islands, using diffusers, on two of the PAs. The impacts from moving those PAs are included in Section 4. The following is a summary of the actions proposed in the DMMP by PA.

PA 229 – Use the PA as in the past, but move the discharge pipe to the two or three spots available on nonvegetated mounds and let the material run out to the east. Dredging and disposal operations November through February, inclusive, when seagrass is dormant and birds are not nesting.

PA 230 – Use the site, if needed in the future, with seasonal restrictions for bird nesting and seagrass growth, after surveying for suitable discharge points to avoid seagrass and bird use areas, as much as possible, before each use.

PA 231 – Use the PA with the same restrictions as PA 230.

PA 232 – Continue placing dredged material at the current site, but spread it along the PA in as thin a layer as possible to limit the depth of seagrass burial, using a diffuser at the end of the pipe to reduce discharge energy and move the pipe frequently to facilitate thin layer placement. In order to help retain more material on the islands, the south and west boundaries will be expanded to enclose all of the islands. Its current and revised position and boundaries are documented in Figure 1-2f. This plan will be reviewed before each dredging event to see if changes in the management plan are needed.

PA 233 – Move the disposal site farther west and south to deeper water (greater than 4.5 feet deep) to avoid seagrass and minimize the effects of the turbidity plume, designate as PA 233A. Its current and revised position and boundaries are documented in Figure 1-2f.

PA 234 – Move this site about 1.5 miles to the west to join with PA 233A. Its current and revised position and boundaries are documented in Figure 1-2f.

PA 235 – Use only for dredged material from the section of the GIWW for which it was established. This will allow sufficient time for seagrass to recover between cycles (9 years) and reduce the amount of material placed in the site. Disposal will take place during the November 1 to February 28 dredging window when seagrass is normally dormant and the dredge pipe moved frequently to prevent excessive build-up of material in any one location. Sandy material may be used to build up the mounds for more bird use in the future. Since the mounds are outside (west of) the boundary of the PA, the site will have to be expanded in the FEIS to include the mounds for beneficial placement of sandy material, if any is available. Its current and revised position and boundaries are documented in Figure 1-2f.

PA 236 – Follow the same disposal procedure designated for PA 235, should it become necessary to use this site in the future.

PA 239 – Continue use of the present disposal practice.

PA 240 – Continue the present disposal practice in this semiconfined site, since it is seldom used and has little volume to flow out into shallow water.

2.11.7 Emmord's Hole

The modeling group from WES, which was conducting all hydrodynamic and sediment transport modeling for the project, examined the impacts should Emmord's Hole be used. The general location was determined from the region's bathymetry, based on the observation of Dr. Ken Dunton that seagrass is not likely to be found in the Laguna Madre below a depth of 4.5 feet. The rest of this paragraph is based on the information found in Chapter 9 of Teeter et al. (2003). The area is generally bounded by 27°25′34″ to 27°30′32″ N and 97°19′04″ to 97°21′29″ W and depths as great as 6.5 feet mean low low water (MLLW) are found in a some portions. The area below a depth of 5.7 feet MLLW is 420 acres, below a depth of 5.25 feet is 519 acres, below a depth of 4.9 feet is 2,050 acres, and below a depth of 4.1 feet is 5,755 acres. The area below a depth of 5.25 feet was chosen for disposal in the model run since it allowed assurance that there should be no seagrass there, as confirmed by field observations. The total amount of material deposited was the combined per-cycle amounts normally placed in PAs 186–189, or 555,400 cy of maintenance material. As noted, it was placed in the center of the area below a depth of 5.25 feet, and 70 percent of the placement, in the model, was laid onto the bed in a 24-hour period in early October, while the remaining 30 percent was injected into the water column at the same location over the following 5 days. The footprint of the bed placement was a 519-acre oval, roughly 6,300 feet long in the north-south direction and 3,600 feet in the east-west direction (see Figure 9.5, Teeter et al., 2003). Within 820 feet of the edge of the footprint, dredged material deposition depth was less than 0.4 inches. For the rest of the month of October, TSS was elevated above the no-disposal scenario about 13 mg/L in an area 9.3 miles north and 2.5 miles east. The 20 percent isopleth was displaced north 7.5 miles, on to seagrass beds, and east up to 0.6 miles, which carried it across the GIWW. During the remainder of the year, monthly average TSS values increased by no more than 7 mg/L and the 20 percent isopleth was displaced only around 500 feet, which does not reach seagrasses. Comparing the model runs with empirical data, Teeter et al. (2003) found TSS elevated within 985 feet of the discharge point in sampling in the Upper and Lower Laguna Madre in 2000. The model indicated TSS elevation of 26 mg/L roughly 1,150 feet north and south of the discharge point. Of course, the model put a much larger amount of material on the bed than occurs in actual dredging and can, therefore, be considered conservative. Based on a 3-year cycle, Teeter et al. (2003) determined that the useful life of Emmord's Hole, for all material normally placed in PAs 186–189, would be 183 years.

The DMMP includes only PAs 184–188 as potentially using Emmord's Hole as an alternative PA, which was not known when the modeling was initiated, since the DMMP was not completed at that time. The model used only 80 percent of the 696,300 cy that is the total per-cycle amount of material from the PAs 184–188. However, Emmord's Hole is not intended to completely replace these PAs, but to only act as a placement location of last resort when dredged material normally designated for PAs inside the Congressionally authorized PINS boundary is moved to these PAs. This will prevent an overload of material at these PAs that could affect nearby seagrass beds that are not usually affected by current placement practices. The ICT will review this issue prior to use and make recommendations to the USACE for managing the material in the area. Additionally, the frequency of PAs

186–189 used in the model was roughly 3 years, while the average frequency of PAs 184–188 used in the maintenance program is 6.2 years, ranging from 3.3 years for PA 188 to 11.6 for PA 184. In any case, Emmord's Hole will only be used for placement when the ICT recommends it be used because of necessity.

2.12 REFINED COST ESTIMATE

2.12.1 Introduction and Methodology

Several different alternative methods for dredging and placement of the shoaled material in the GIWW were identified. This was all provided to Moffatt & Nichol Engineers (Moffatt & Nichol), under contract to the USACE, to perform detailed cost estimates utilizing the Cost Engineering Dredge Estimating Programs (CEDEP). The purpose of the cost estimates was to obtain a comparative analysis or "relative difference" between the alternatives and to allow the USACE to determine whether any alternative is not economically feasible.

The cost estimate for each alternative included the mobilization and demobilization of equipment (mob/demob), daily plant costs (i.e., dredge, pipeline, and all support equipment) fuel, and labor costs. Site preparation costs were determined, where necessary, and added to the dredging costs to obtain a total unit cost and total 50-year costs for each alternative.

Delay times due to barge traffic, adverse weather conditions, and other factors are based on data from previous dredging projects that have occurred throughout the Laguna Madre portion of the GIWW. Daily dredge logs from previous dredging projects, vessel traffic records from 1995–2000, and meteorological information for the Lower Laguna Madre were used to determine historical downtime summaries. This information was compiled and used to produce a table in which were calculated the travel speeds for the hopper dredges, tugboats, and dump scows that were carried through all estimates in the appropriate alternatives.

All dredging volume estimates were based on an analysis of the data provided in Table 2-33, which is a compilation of dredging records for the GIWW in the Laguna Madre from November 1948 to April 1995 (46.4 years). This information was provided by the USACE and was used to determine per-cycle discharge quantities, per-cycle dredging areas, shoaling rates, number of dredging episodes, and the sand content of the dredged material. Based on these historical records, an average dig face for the dredge cutterhead was determined for each Reach of the GIWW throughout the Laguna Madre. The USACE provided the contractor overhead, profit, and bond rates to include in the dredge costs. The USACE also provided the contingency, design, construction management, and administration rates.

Equipment cost factors, area factors, and economic indexes were derived from the U.S. Army Corps of Engineers Construction Equipment Ownership and Operating Expense Schedule, Region VI, EP 1110-1-8 (Vol. 6), 31 Aug. 01.

Prior to beginning the estimates, a survey of the U.S. dredging fleet was accomplished to determine what dredge plant was available to perform the work. Several different types of dredging equipment were surveyed, including hopper dredges, cutterhead dredges, and clamshell dredges with dump scows. Several industry publications and a dredging industry monthly report were utilized for the dredging fleet survey. From the survey, it was established that a sufficient number of cutterhead dredges and smaller clamshell dredges (<10 cy) were available in the Gulf Coast region. It was also found that a majority of the hopper dredging work occurs on the Southern Atlantic Waters of the U.S., Gulf of Mexico Coast, and Lower Mississippi River system of the U.S. By using New Orleans as the mobilization point, it allowed for adequate competition from all of the Gulf fleet dredges.

During the course of the dredging fleet analysis, it was determined that there are only three hopper dredges in the U.S. fleet with a sufficiently shallow draft to work in the GIWW. Of the three hopper dredges, one has currently been sold to an overseas firm and taken out of the country. This leaves only two viable hopper dredges to perform the work.

The assumptions that were used during performance of the cost estimates are given below. The general assumptions that were used on all alternatives estimates are listed first, with a brief explanation. Following the general assumptions are the different alternative estimates and any general or specific assumptions that were pertinent to the estimates for a given alternative or sub-alternative.

2.12.2 General Assumptions for All Alternatives

Estimates were determined for each Reach used by the ICT, except for special cases that were determined by specific segments to remain consistent with the preliminary alternative analysis and preliminary cost estimates that had been performed (Sections 2.3 through 2.10) and to keep the number of estimates reasonable. The assumptions were kept consistent throughout all estimates so the alternative costs could be compared on an equal basis.

- All dredging and site preparation costs assume a 50-year project life.
- The dump scows located on the West Coast were not included in the idle scow location calculations because of the long distances required to transport the equipment to the project site and the short dredging durations.
- No foreign fleet vessels can be used because of the Jones Act (U.S. Code Title 46, Appendix, Chapter 12, Section 292).
- The wage rates are based on contractor payroll information from previous dredging projects.
- The mob/demob costs for all hydraulic dredges, hopper dredges, and smaller clamshell dredges (<10 cy) are based on equipment being mobilized to the project site from as far away as New Orleans (approximately 600 miles). The demobilization costs are based on the equipment being demobilized and stored at Corpus Christi.

- The mob/demob costs for the hydraulic dredge estimates were revised for each estimate depending on the length of pipeline and the number of booster pumps necessary to complete the work.
- No real estate acquisition fees or rights-of-way for areas where the discharge pipeline crosses private properties were determined for any of the upland alternatives or offshore alternatives
- No environmental constraints, environmental impacts, or other resource impacts were considered during the development of the cost estimates.
- No costs associated with an Ocean Dredged Material Disposal Site (ODMDS) EIS or permitting were determined during the development of the cost estimates nor included in the estimates.

2.12.3 Alternative 1: Current Method

Alternative 1 is the present practice for maintenance dredging of the GIWW through the Laguna Madre. A cutterhead dredge places the material, via pipeline, into the established open-water PAs in Reaches 1, 2, 4, 5, and 6. The established PAs for Reach 3 are upland confined or semiconfined sites. The open-water PAs are spaced throughout the project length, so that the maximum pumping distance for the cutterhead dredges is approximately 5,000 feet, negating the need for booster pumps.

Given that this is the No-Action alternative, Alternative 1 will serve as the basis for comparison with the other alternatives.

2.12.3.1 Assumptions General to Alternative 1

Alternative 1 requires no general assumptions except those common to all alternatives.

2.12.3.2 Specific Assumptions

- The estimates for Alternative 1 utilize a 20-inch Hydraulic Cutter-Suction Dredge.
- The material is discharged into the existing open-water PAs.
- No levee work was assumed for the existing open-water PAs that are semiconfined or confined.
- Reach 3 is based on placement at the existing upland sites.
- The estimate for Reach 3 assumes shore/levee work associated with the upland sites only during each dredging cycle.

2.12.4 Alternative 2: Offshore

Alternative 2 calls for maintenance dredging and placement offshore. Dredged material would be placed at the current designated ODMDSs located near the Mansfield Pass or Brazos Santiago Pass, or pumped 2 miles offshore from the barrier island. Various dredging and placement methods were considered, including hopper dredges, cutterhead dredges pumping into dump scows, clamshell dredges with dump scows, and cutterhead dredges by pipeline.

Prior to performing the hopper dredge estimates for Alternative 2, several questions were raised by the ICT regarding the operation of hopper dredges in the GIWW (sub-alternatives 2A1 and 2A2): could hopper dredges back down the GIWW to the passes rather than making a loop between two passes, could commercial tug and barge traffic safely pass hopper dredges working in the GIWW, and would hopper dredges working in the GIWW be restricted to one-way traffic or could they safely pass each other. Captain Carl E. Bowler, a Master Mariner/Ship Pilot with 26 years' experience, was engaged to determine the viability of hopper dredges working in the GIWW relative to the above questions.

Captain Bowler spoke with local towing companies, the director of the Gulf Intracoastal Canal Association, hopper dredge owners, and the Commander of United States Coast Guard (USCG) District 8 regarding the use of hopper dredges in the GIWW. Based on the above conversations and his own practical experience piloting vessels of this size and larger, Captain Bowler determined that it would be infeasible and unsafe for a hopper dredge to back down any considerable distances in the operating conditions present in the GIWW. Therefore, without turning basins being created, the hopper dredges would need to make a loop between two offshore passes, adding long transit distances to the project.

Relative to commercial tug and barge traffic safely passing the hopper dredges and hopper dredges passing each other, it was determined that this was feasible if weather conditions permitted. However, the hopper dredge would have to discontinue work and move to the edge of the channel to allow commercial traffic and other hopper dredges to pass safely. An increase in vessel traffic created by additional hopper dredges could potentially cause delays to normal vessel traffic flow.

Another option for Alternative 2 (sub-alternatives 2B1 and 2B2) was to use dump scows to transport the dredged material to offshore disposal sites. The important issue with these two sub-alternatives was the availability of clamshell dredges and dump scows capable of performing the work. Based on several dredging industry surveys, taken from different periods of the year, the idle capacity of the dump scow fleet was established. The quantity, location, and ownership of the various dump scows in the U.S. fleet were then compared with the optimum quantity required to perform the dredging work. An estimated percentage of the idle dump scow fleet, for each sub-alternative was then calculated. In addition, the number of scows utilized was varied, to compute the effect on the dredging costs when less than optimum scow capacity was used. This allowed for a determination of how many dredging contractors possessed a sufficiently large idle scow capacity to perform the dredging work. It was concluded that only one dredging company owned sufficient idle fleet capacity to bid the work for any of the sub-alternatives that required more than three dump scows (Table 2-34).

To determine the effect on cost of single bidder projects versus multiple bidder projects, a study of USACE dredging contracts awarded from 1992–2001 was undertaken. The final bid percentage relative to the government estimate was compared for dredging projects with multiple bidders to dredging projects with single bidders. For the Galveston District, it was found that single-bidder projects averaged 15 percent over the government estimate while multiple bidder projects (three bids received) averaged

TABLE 2-34

DUMP SCOW COMBINATIONS

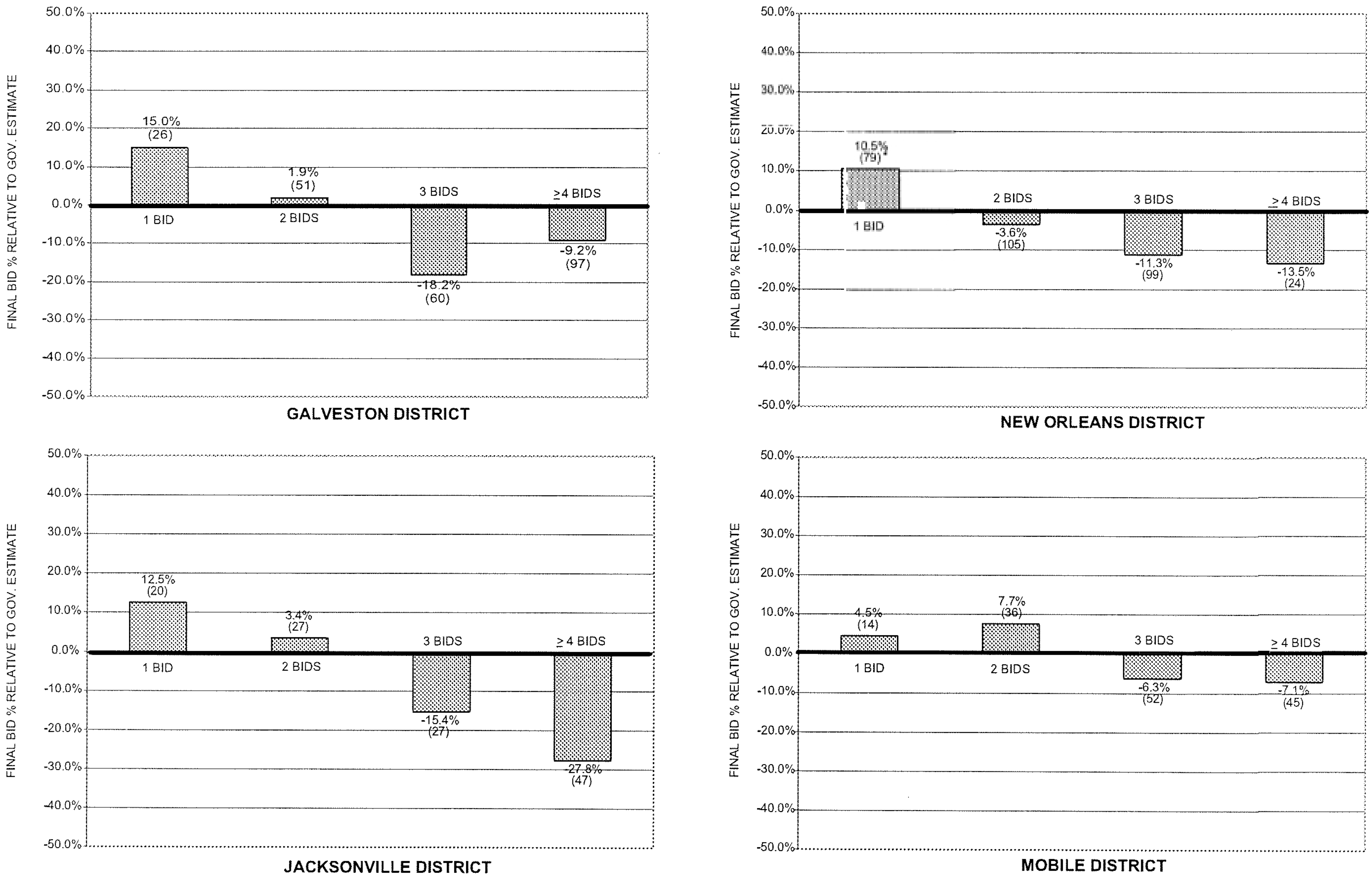
No. of Scows Utilized (ea.)	Total Scow Capacity (CY)	Production Rate (CY/HR)	Operating Time (Hrs/Mo)	Total Idle Scow Capacity (CY)	Percent of Idle Scow Capacity	Optimal Haul Distance (Mi.-One Way)	Actual Haul Distance (Miles-RT)	Likely No. of Bidders (ea.)
Alternative #2B1: Offshore - Hydraulic/Scow								
7	28,000	1865	437	53,150	52.68%		16.53	1
6	24,000	1,865	364	53,150	45.16%		16.53	1
5	20,000	1,865	291	53,150	37.63%		16.53	1
4	16,000	1,865	218	53,150	30.10%		16.53	1
3	12,000	1,865	145	53,150	22.58%		16.53	2[3]
2	8,000	1,865	72	53,150	15.05%		16.53	2
Alternative #2B2: Offshore - Clamshell/Scow								
3	9,000	893	459	74,280	12.12%	16.60	16.53	2
2	6,000	893	230	74,280	8.08%	7.25	16.53	3[4]
Alternative #5A1: Special Cases - PA 220 & 221 (Offshore - Hydraulic/Scow)								
4	16,000	1,300	563	53,150	30.10%		9.99	1
3	12,000	1,300	374	53,150	22.58%		9.99	2[3]
2	8,000	1,300	187	53,150	15.05%		9.99	2
Alternative #5A1: Special Cases - PA 220 & 221 (Offshore - Clamshell/Scow)								
3	9,000	734	459	74,280	12.12%	20.50	11.63	2
2	6,000	734	380	74,280	8.08%	9.25	11.63	3[4]
Alternative #5B1: Special Cases - PA 233 & 234 (Offshore - Hydraulic/Scow)								
7	28,000	1,896	401	53,150	52.68%		17.33	1
6	24,000	1,896	334	53,150	45.16%		17.33	1
5	20,000	1,896	267	53,150	37.63%		17.33	1
4	16,000	1,896	200	53,150	30.10%		17.33	1
3	12,000	1,896	133	53,150	22.58%		17.33	2[3]
2	8,000	1,896	66	53,150	15.05%		17.33	2
Alternative #5B1: Special Cases - PA 233 & 234 (Offshore - Clamshell/Scow)								
4	12,000	893	459	74,280	16.16%	25.90	17.33	2
3	9,000	893	441	74,280	12.12%	16.60	17.33	2
2	6,000	893	221	74,280	8.08%	7.20	17.33	3[4]

Notes:

1.) Clamshell estimates utilize all dump scows greater than 1,500 CY capacity.
2.) All hydraulic estimates utilize all dump scows greater than 3,000 CY capacity.
3.) Second bidder would be a joint venture between Weeks Marine and Norfolk Dredging.
4.) The third bidder could be made up of a combination of C.F. Bean Corporation and Norfolk Dredging (for clamshell
The third bidder could be made up of a combination of Norfolk Dredging and Don Jon Marine,
or Norfolk Dredging and C.F. Bean Corporation (hydraulics pumping into scows).
5.) The idle scow capacity was determined from a dredging industry survey.
6.) There was an average of 3 bidders for dredging projects located in the GIWW, for the years 1990 to 2000.
7.) All site prep estimates involving clamshell work to dredge out access channels utilize a 10 CY clamshell dredge wit

Figure 2-1

COST ANALYSIS VERSUS NUMBER OF BIDS



Source: Moffat & Nichol Engineers

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18 percent under the government estimate (Figure 2-1). A single-bidder scenario could potentially escalate the cost of the dredging work by 30 percent or more above a multiple-bid scenario.

In addition to the idle scow capacity resource analysis, the location of the idle dump scows in the U.S. fleet was also determined. Based on industry reports, the distance to the project site from the different idle scow locations was calculated. A weighted-average distance was then used to determine the cost to mobilize the required number of dump scows to the project site for each sub-alternative.

The general assumptions for Alternative 2 are listed below followed by specific assumptions related to the different sub-alternatives.

2.12.4.1 Assumptions General to Alternative 2

- All estimates for Alternative 2 that utilize dump scows working in the main channel of the GIWW utilize a 1,600-horsepower (hp) tugboat instead of a workboat. This is required because the dump scow will need to be moved to allow barge and other commercial boat traffic to navigate past the work areas. While the dump scow is alongside the dredge or spider barge, there is not enough room for commercial traffic to safely navigate past the work area.
- It was assumed that larger clamshell dredges (>10 cy) and dump scows were mobilized from the East Coast, based on the resource demand analysis that was performed.
- The mob/demob costs for the clamshell estimates were revised for each estimate depending on the number of dump scows and tugboats that were needed.
- The hopper dredge and dump scow capacities were reduced to account for a draft limitation of 10.5 feet due to shoaled conditions in the GIWW.
- Unlimited overflow is permitted from the hopper dredges and dump scows during loading operations. No constraints due to water quality were taken into account, thus no costs were included for this.

2.12.4.2 Alternative 2A1: Offshore – Hopper Dredge w/Turning Basins (Reach 6 only)

- Alternative 2A1 assumes a turning basin is located at the north end of each segment in Reach 6 to reduce the distance and travel time for the hopper dredge. Due to the large differences in dredging frequency for the different segments within each reach, it was determined that each segment would need a turning basin to keep transit times as short as possible.
- Turning basins are 310 feet in diameter, dredged to a depth of –16 feet, and centered over the GIWW (Figure 2-2). This is based on the requirements of USACE and U.S. Navy engineering design guide manuals.
- The turning basin dredge quantities within the GIWW channel limits are deducted from the GIWW total dredging quantities.

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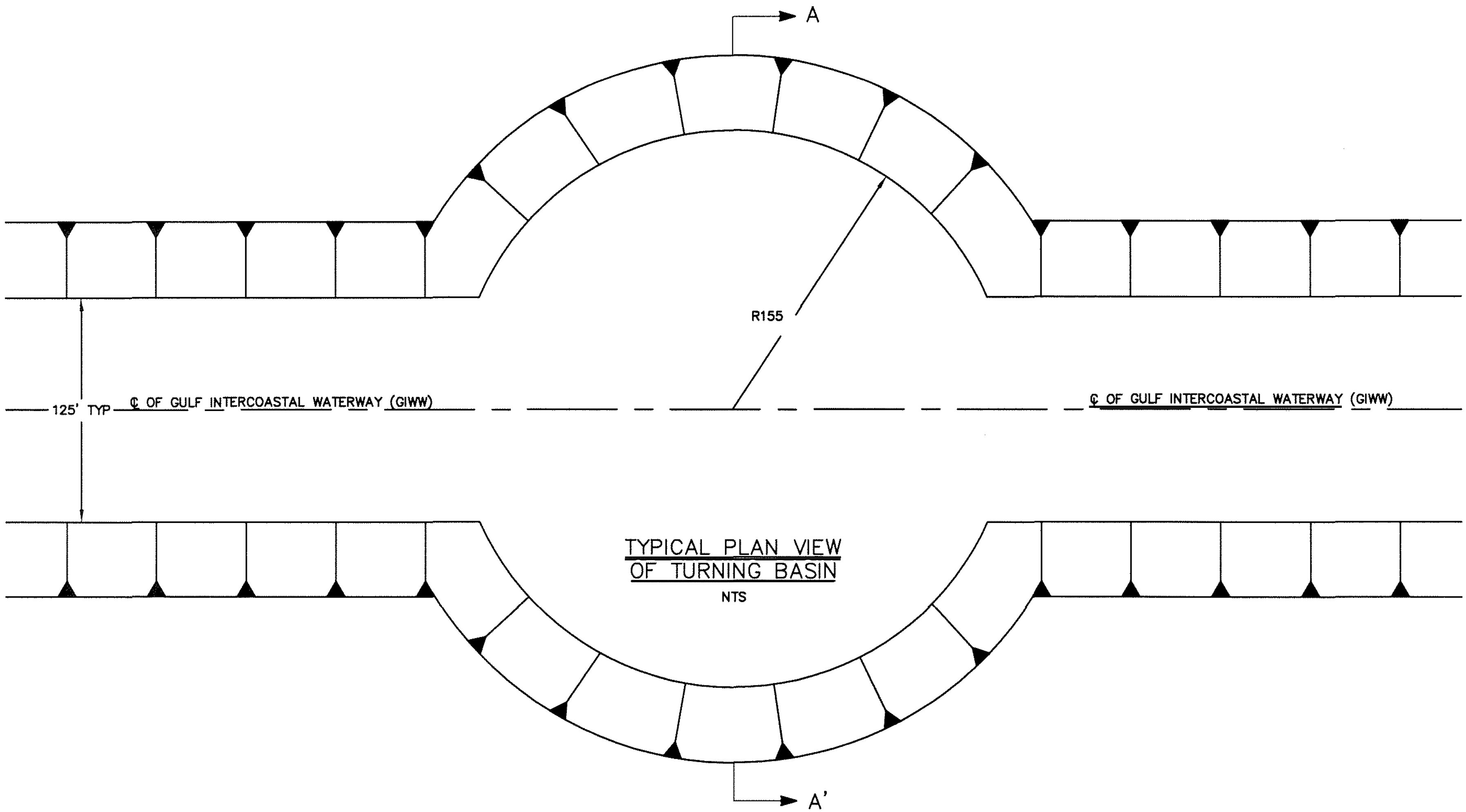
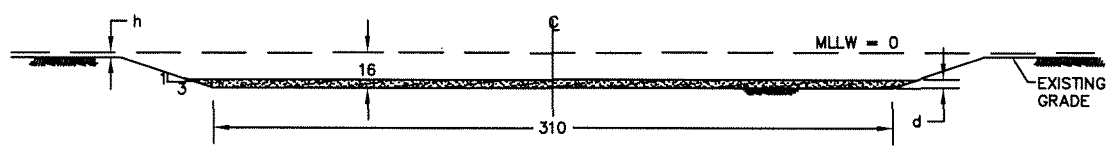


TYPICAL PLAN VIEW OF TURNING BASIN

NTS



TYPICAL TURNING BASIN CROSS SECTION A–A'

NTS

NOTE:

1. THE DEPTH OF TURNING BASIN IS 16 FT BELOW MLLW. LOCAL WATER DEPTH, h, VARIES AT EACH TURNING BASIN.
2. SHOALING DEPTH, D, IS SIMILAR TO GIWW SHOALING DEPTH.

Source: Moffat & Nichol Engineers

Figure 2-2

LAGUNA MADRE

TYPICAL TURNING BASIN

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- The dredged material is placed at the BIH ODMDS.
- The turning basins are dredged by a 10 cy clamshell dredge with dump scows prior to each cycle of GIWW dredging. Material is placed at the BIH ODMDS.
- All costs for dredging the turning basins are included in the site preparation costs.
- The turning basins are not maintained on a yearly basis but are dredged prior to each cycle.
- Shoaling rates for turning basins are based on shoaling rates determined for the different reaches of the GIWW from previous dredging records.

2.12.4.3 Alternative 2A2: Offshore – Hopper Dredge without Turning Basins (Reach 6 only)

- Alternative 2A2 assumes no turning basins are available for the hopper dredge.
- The hopper dredge will travel in a loop and dispose of the dredged material at the Port Mansfield ODMDS and then at the BIH ODMDS, etc.

2.12.4.4 Alternative 2B1: Offshore – Hydraulic/Scow (Reach 6 only)

- Alternative 2B1 is based on utilizing a hydraulic cutterhead dredge to pump the dredged material, via pipeline, to a spider barge, which loads the material into dump scows. The dump scows are then transported by tugboat, to the ODMDSs.
- Alternative 2B1 assumes a pipeline length of 5,000 feet leading to the spider barge.
- The effective capacity of the scow is reduced to account for the material type and the large water volume produced by the hydraulic cutterhead dredge.
- Due to the narrow channel widths, the spider barge is only able to load from one side. The dredge would discontinue pumping material during dump scow change outs.
- Based on loading times, only 3,000 cy scows and larger were utilized.

2.12.4.5 Alternative 2B2: Offshore – Clamshell (Reach 6 only)

Alternative 2B2 assumes a 26 cy clamshell dredge.

The average size scow utilized for the estimate was a 3,000 cy scow.

2.12.4.6 Alternative 2C: Offshore – Hydraulic (2 miles offshore)

- All estimates for Alternative 2C assume an 8-foot-deep channel from the GIWW to Padre Island to allow for the pipeline and booster pump(s).
- There are no possible pipeline corridors for Reaches 2, 3, and most of 1 and 4 due to the PINS. Only areas of Reach 1 and 4 that were outside the Congressionally authorized boundaries of the Padre Island National Seashore were estimated.

- The pipeline channels are dredged by a 10 cy clamshell dredge with dump scows prior to each cycle of GIWW dredging and material dredged is placed at the ODMDSs.

- For Reaches 1, 4, and 5, it is assumed that the pipeline access channel will shoal back to its original condition prior to the next cycle of dredging. For Reach 6, it is assumed that the pipeline access channel will never shoal in any greater than its original condition.

- All rights-of-way and/or easements will be obtained for placing the pipeline across Padre Island, thus no costs were included for this.

- Culverts or pipeline tunnels will be provided to cross any streets or public right-of-ways on Padre Island, thus no costs were included for this.

- The pipeline will be buried in areas of beach access, but no costs were included for this.

2.12.5 Alternative 3: Upland

Alternative 3 is based on maintenance dredging by cutterhead dredge and transporting the material, via pipeline, to designated upland locations within each segment. For Alternative 3A, the upland locations are completely confined by earthen levees built with on-site borrow material. For Alternative 3B, the upland sites consist of thin-layer placement (1 foot thick) of the dredged material at the upland locations.

2.12.5.1 Assumptions General to Alternative 3

Alternative 3 requires no general assumptions except those common to all alternatives.

2.12.5.2 Specific assumptions:

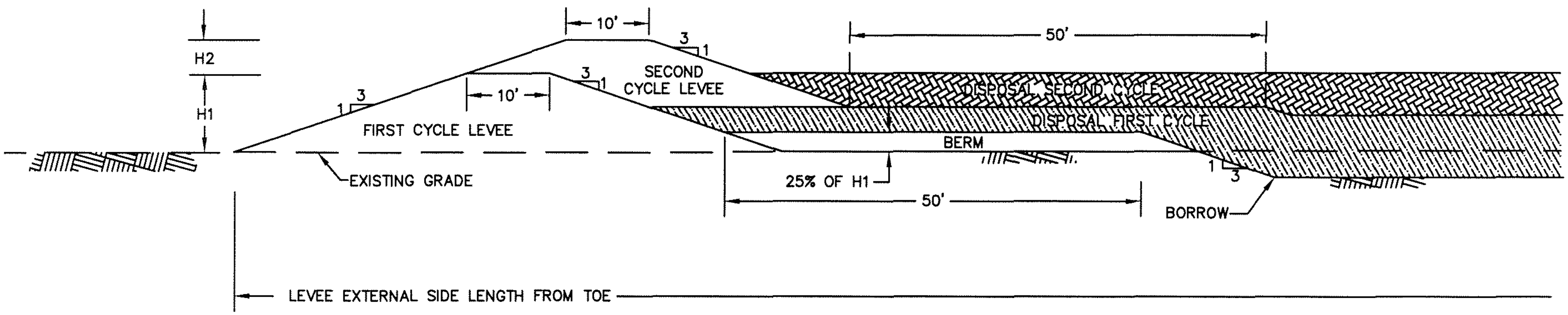
- The levee quantities for the upland sites located in each segment were combined to get a total levee volume to be constructed within each Reach.

- There is no road access to the upland sites. All equipment access will be from channels dredged from the GIWW to shore locations near the upland sites.

- All rights-of-way have been obtained from the shoreline to the upland confined locations, thus no costs were included for this.

- A weighted-average, based on the dredging volumes for each segment, is used to determine the pipeline distances for each Reach.

- The size of each upland confined site is based on levees built to 30 feet in height to contain 50 years of dredged material. The levees are constructed utilizing on-site borrow material (Figure 2-3). All levees assume 2 feet of freeboard and 2 feet of ponding.



UPLAND PLACEMENT AREAS
TYPICAL SECTION
NTS

NOTE:

1. ALL DIMENSIONS SHOWN ARE TYPICAL
2. ACTUAL LEVEE HEIGHT AND DISPOSAL DEPTH DEPEND ON SEGMENT AND CYCLE

Source: Moffat & Nichol Engineers

Figure 2-3

LAGUNA MADRE
UPLAND PLACEMENT AREA

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- PBS&J provided the theoretical locations of the 14 new upland sites for Reaches 1, 2, 4, 5, and 6. Reach 3 uses the existing upland sites for containment. The upland site sizes varied from approximately 30 to 510 acres. The approximate total acreage (measured from the outside toe of levee) for all 14 sites was 2,332 acres.

- All site preparation estimates for Alternative 3 assume an 8-foot-deep channel from the GIWW to the shoreline near the new upland sites to allow for equipment access to build the levees and also to provide access for the pipeline and booster pump(s).

- Since the estimate for Reach 3 utilizes the existing upland placement sites currently available, no access channel dredging is necessary.

- The site preparation estimate for Reach 3 assumes that the existing confined and semiconfined PAs will be completely confined. The external size of the PA is assumed to be the size provided by the USACE for the existing PAs. Confinement levees were built around areas of the existing PAs that are not currently confined.

- Access channels are dredged by a clamshell dredge with dump scows prior to each cycle of GIWW dredging and placed at the ODMDSs.

- The effective capacity of the scow is reduced to account for the material type and limited depth of 8 feet.

- The mobilization costs were increased to allow for transport of the scows from the East Coast.

- The access channels to the upland sites are not maintained on a yearly basis. Dredging of the access channel will occur prior to each dredging cycle (to allow access for equipment to construct levees).

The shoaling rates for the access channels are based on the shoaling rates determined for the different reaches of GIWW.

2.12.6 Alternative 4: Open Bay

Alternative 4 is based on maintenance dredging by cutterhead dredge and placement, via pipeline, at the existing PAs alongside the GIWW. The limits of the existing PAs were provided by the USACE. Alternative 4A is identical to the current method. Alternative 4B is based on confining the existing PAs with levees to contain the material inside the PA. Alternative 4C is based on semi-confinement of the existing PAs to direct the flow of the dredged material away from the GIWW.

The confinement levees and associated costs for Alternatives 4B and 4C are based on conceptual levee cross sections that were developed by Shiner Moseley and Associates, Inc. for the USACE. The different levee sizes are based on the water depths that occur at each PA. Where existing islands occur within a PA, earthen levees were built from on-site borrow material. Locations that involved levees being placed in open-water were based on the conceptual levee sections, consisting of side-cast levees, gravel toe levees, or geotubes, all of which would be armored with graded riprap or articulating block mats. The site preparation costs for each PA are based on constructing the lower armored section of the levee first, then constructing the earthen expansion section of the levee in stages, prior to each cycle of GIWW dredging, up to the height required to contain 50 years of dredged material.

2.12.6.1 Assumptions General to Alternative 4

Alternative 4 requires no general assumptions except those common to all alternatives.

2.12.6.2 Specific assumptions:

- The dredged material is placed at the existing open-water PAs with the required containment levees.
- The levee quantities for the different open-bay confined and open-bay semiconfined PAs were combined to get a total levee length or volume to be constructed within each Reach.
- Reach 3 was not included in any of the estimates for Alternative 4. Reach 3 was completely confined in Alternative 3.
- A weighted-average, based on the dredging volumes for each PA, was used to determine the pipeline lengths for each Reach.
- Based on water quality constraints, the minimum PA size for 50-year containment was 80 acres or the entire existing PA, if the site was smaller than 80 acres.
- All levee sections were built up to the height required to contain 50-years of dredged material. All fully confined levees assume 2 feet of freeboard and 2 feet of ponding.
- The semiconfined levee sections are built around three sides of the PA and direct the flow of sediments away from the GIWW directly after dredging, while retaining some of the dredged material.
- The semiconfined levees are not required to contain, dewater and elevate the dredged material, so the final levee height is considerably less than the fully confined levees.
- The site preparation costs are based on the lowest cost conceptual levee section alternative (i.e., rock dike, geotube, or earthen levee).
- The weir design and costs are based on information provided by the USACE.

2.12.7 Alternative 5: Special Cases

The estimates for Alternative 5 are special case scenarios that deal with high dredging volume, high frequency of use PAs that are near the passes to the Gulf. Similar to Alternative 2, the material is placed at the ODMDSs located near the Mansfield and Brazos Santiago Passes. The dredging and placement is evaluated using several different methods, including hopper dredges, cutterhead dredges pumping into dump scows, clamshell dredges with dump scows, and cutterhead dredges by pipeline. The same issues/assumptions that are pertinent to Alternative 2 are also relevant for

Alternative 5, such as the need for turning basins for the hopper dredges, the idle fleet capacity for the scenarios that utilize dump scows, varying the number of scows to determine the effect on costs, and the likely number of bidders based on the resource demand analysis.

2.12.7.1 Assumptions General to Alternative 5

- All estimates that utilize dump scows working in the main channel of the GIWW utilize a 1,600-hp tugboat instead of a workboat. This is required because the dump scow will need to be moved to allow barge and other commercial boat traffic to navigate past the work areas. While the dump scow is alongside the dredge or spider barge, there is not enough room for commercial traffic to safely navigate past the work area.

- It was assumed that larger clamshell dredges (>10 cy) and dump scows were mobilized from the East Coast, based on the resource demand analysis that was performed.

- The mob/demob costs for the clamshell estimates were revised for each estimate depending on the number of dump scows and tugboats that were needed.

- The hopper dredge and dump scow capacities were reduced to account for a draft limitation of 10.5 feet due to shoaled conditions in the GIWW, with the exception of Alternative 5A1-4-01 which loads the scows in deeper water.

- Unlimited overflow is permitted from the hopper dredges and dump scows during loading operations. No constraints due to water quality have been taken into account, thus no costs were included for this.

2.12.7.2 Alternative 5A1-4-01 and 5B1-5-01: Offshore – Hydraulic/Scow

- Alternative 5A1-4-01 is for PAs 220 and 221. Alternative 5B1-5-01 is for PAs 233 and 234.

- Alternative 5A1-4-01 assumes the scows are loaded in the deeper water of the Port Mansfield Channel, therefore the channel depth does not limit the scow draft.

- The effective capacity of the scow is reduced to account for the material type and the large water volume produced by the hydraulic dredge.

- Due to the narrow channel widths the spider barge is only able to load from one side. The dredge would discontinue pumping material during dump scow change outs.

- Based on loading times, only 3,000-cy scows and larger were utilized.

2.12.7.3 Alternatives 5A1-4-03 and 5B1-5-02: Clamshell – Offshore

- Alternative 5A1-4-03 is for PAs 220 and 221. Alternative # 5B1-5-02 is for PAs 233 and 234.

- Alternatives 5A1-4-03 and 5B1-5-02 assume a 26-cy clamshell dredge.

- The effective capacity of the scow is reduced to account for the material type and limited depth.
- The average size scow utilized for the estimate was a 3,000-cy scow.

2.12.7.4 Alternative 5A2, 5B2, and 5C1: Hopper w/Turning Basins

- Alternative 5A2 is for PAs 220 and 221. Alternative 5B2 is for PAs 233 and 234. Alternative 5C1 is for Reaches 4, 5, and 6 in the Lower Laguna Madre (LLM).
- Alternative 5A2 assumes a turning basin for the hopper dredges is located at the north end of PA 220 and the south end of PA 221.
- Alternative 5B2 assumes one turning basin is located at the north end of PA 233.
- Alternative 5C1 assumes a turning basin is located at the north end of each segment in each reach, except segment 13 (Figure 1-1).
- Turning basins are 310 feet in diameter, dredged to a depth of –16 feet, and are centered over the GIWW (Figure 2-2). This is based on the requirements of USACE and U.S. Navy engineering design guide manuals.
- The turning basin dredge quantities that are within the GIWW channel limits are deducted from the GIWW total dredging quantities.
- The turning basins are dredged by a clamshell dredge prior to each cycle of GIWW dredging and the material placed at the Port Mansfield or BIH ODMDS.
- The costs for dredging the turning basin are included in the site preparation costs.
- The turning basins are not maintained on a yearly basis but are dredged prior to each cycle of GIWW dredging.
- The shoaling rates for turning basins are based on shoaling rates determined for the different reaches of the GIWW.

2.12.7.5 Alternative 5A3 and 5B3: Hydraulic – Offshore

- Alternative 5A3 is for PAs 220 and 221. Alternative 5B3 is for PAs 233 and 234.
- Alternative 5A3 assumes that the pipeline runs out the Port Mansfield Channel and 2 miles offshore. There are no site preparation costs for this estimate.
- Alternative 5B3 assumes an 8-foot-deep channel from the GIWW to Padre Island to allow for the pipeline and booster pump(s).
- The pipeline channels are dredged by a 10-cy clamshell dredge with dump scows prior to each cycle of GIWW dredging and placed at the BIH ODMDS.
- It is assumed that the pipeline access channel will shoal back to its original condition prior to the next cycle of dredging.

- It is assumed that all rights-of-way will be obtained for placing the pipeline across Padre Island, thus no costs were included for this.
- It is assumed that culverts or pipeline tunnels will be provided to cross any streets or public right-of-ways (ROWs) on Padre Island, thus no costs were included for this.
- The pipeline will be buried in areas of beach access, but no costs were included for this.

2.12.7.6 Alternative 5C2: Hopper without Turning Basins in the LLM

- Alternative 5C2 assumes no turning basins are constructed for the hopper dredge.
- The hopper dredge will travel in a loop and dispose of the dredged material at the Port Mansfield ODMDS and the BIH ODMDS.

2.12.8 Dredged Material Management Plan Alternative

The DMMP estimates are based on the DMMP prepared by the USACE with the assistance of the ICT, summarized in Section 2.11 and provided in Appendix A. The DMMP represents the least environmentally damaging practical placement options for the different PAs and is based on the results of all previous studies that have been performed to date. The intent of the DMMP is to reduce impacts to seagrasses and also manage the sites for bird use, vegetation control, and recreational use. The dredging and placement varies among the PAs depending on the option in the DMMP.

Although the DMMP has placement recommendations for each PA, the cost estimates were performed on a Reach basis, utilizing the same assumptions as in the above estimates. This allowed a cost comparison with Alternatives 1–5 on an identical basis. The general assumptions listed at the beginning of the document apply to all estimates, including the DMMP estimates. All levees constructed for the DMMP are earthen levees built from on-site borrow material and utilize similar assumptions as Alternative 4.

2.12.9 Results

The final cost estimates developed for the USACE by Moffatt & Nichol are summarized and presented by each alternative described above in Table 2-35. The complete table can be viewed on the USACE website at www.swg.usace.army.mil under Laguna Madre Environmental Studies, Alternatives Cost Analysis. As can be seen from an examination of Table 2-35, the cost per cubic yard ($/cy) ranges from $1.94 to $3.47 for the present practice. It should be noted that $3.47/cy for the present practice for Reach 5 is an artifact of the analysis by Reach and is not representative of actual costs for dredging Reach 5. This is because Reach 5 requires only infrequent maintenance and is always included with a contract that covers other portions of the Laguna Madre GIWW. However, the cost is representative of what would be expected if Reach 5 were maintained as a unit separate from the rest of the Laguna Madre GIWW, and since all alternatives were treated the same, it provides a good basis for comparison.

TABLE 2-35

COST ESTIMATE FOR PLACEMENT ALTERNATIVES FOR THE GIWW,
PORT ISABEL TO CORPUS CHRISTI BAY

Alternative	Reach	Segment/PA	Dredging Method	Disposal Site	Unit Cost ($/CY)	Increase in Cost (Ratio) over Current Method
#1	1	1-3	Hydraulic	Current PA	$1.96	
#1	2	4-5	Hydraulic	Current PA	$2.19	
#1	3	6-9	Hydraulic	Current PA	$2.36	
#1	4	10-13	Hydraulic	Current PA	$2.04	
#1	5	14-15	Hydraulic	Current PA	$3.47	
#1	6	16-18	Hydraulic	Current PA	$1.94	
#2A1	6	16-18	Hopper	Offshore	$32.14	16.57
#2A2	6	16-18	Hopper	Offshore	$36.53	18.83
#2B1	6	16-18	Hydraulic-7 Scows	Offshore	$6.26	3.23
#2B1	6	16-18	Hydraulic-6 Scows	Offshore	$6.21	3.20
#2B1	6	16-18	Hydraulic-5 Scows	Offshore	$6.21	3.20
#2B1	6	16-18	Hydraulic-4 Scows	Offshore	$6.78	3.49
#2B1	6	16-18	Hydraulic-3 Scows	Offshore	$7.88	4.06
#2B1	6	16-18	Hydraulic-2 Scows	Offshore	$11.04	5.69
#2B2	6	16-18	Clamshell-3 Scows	Offshore	$5.62	2.90
#2B2	6	16-18	Clamshell-2 Scows	Offshore	$6.87	3.54
#2C	1	1	Hydraulic	Offshore (2 mi.)	$12.58	6.42
#2C	4	13	Hydraulic	Offshore (2 mi.)	$36.08	17.69
#2C	5	14-15	Hydraulic	Offshore (2 mi.)	$33.78	9.73
#2C	6	16-18	Hydraulic	Offshore (2 mi.)	$13.47	6.94
#3A	1	1-3	Hydraulic	Upland/Confined	$8.93	4.56
#3A	2	4-5	Hydraulic	Upland/Confined	$6.05	2.76
#3A	3	6-9	Hydraulic	Upland/Confined	$3.47	1.47
#3A	4	10-13	Hydraulic	Upland/Confined	$6.70	3.28
#3A	5	14-15	Hydraulic	Upland/Confined	$18.10	5.22
#3A	6	16-18	Hydraulic	Upland/Confined	$11.40	5.88
#3B	1	1-3	Hydraulic	Upland/ThinLayer	$10.45	5.33
#3B	2	4-5	Hydraulic	Upland/ThinLayer	$7.73	3.53
#3B	4	10-13	Hydraulic	Upland/ThinLayer	$8.70	4.26
#3B	5	14-15	Hydraulic	Upland/ThinLayer	$17.96	5.18
#3B	6	16-18	Hydraulic	Upland/ThinLayer	$13.39	6.90
#4A	1	1-3	Hydraulic	Current PA	$1.96	1.00
#4A	2	4-5	Hydraulic	Current PA	$2.19	1.00
#4A	4	10-13	Hydraulic	Current PA	$2.04	1.00
#4A	5	14-15	Hydraulic	Current PA	$3.47	1.00
#4A	6	16-18	Hydraulic	Current PA	$1.94	1.00
#4B	1	1-3	Hydraulic	Open-Bay/Confined	$5.62	2.87
#4B	2	4-5	Hydraulic	Open-Bay/Confined	$6.28	2.87
#4B	4	10-13	Hydraulic	Open-Bay/Confined	$8.18	4.01
#4B	5	14-15	Hydraulic	Open-Bay/Confined	$5.08	1.46
#4B	6	16-18	Hydraulic	Open-Bay/Confined	$5.31	2.74

TABLE 2-35 (Cont'd)

COST ESTIMATE FOR PLACEMENT ALTERNATIVES FOR THE GIWW,
PORT ISABEL TO CORPUS CHRISTI BAY

Alternative	Reach	Segment/PA	Dredging Method	Disposal Site	Unit Cost ($/CY)	Increase in Cost (Ratio) over Current Method
#4C	1	1-3	Hydraulic	Open-Bay/Semi-Confined	$3.39	1.73
#4C	2	4-5	Hydraulic	Open-Bay/Semi-Confined	$3.85	1.76
#4C	4	10-13	Hydraulic	Open-Bay/Semi-Confined	$5.47	2.68
#4C	5	14-15	Hydraulic	Open-Bay/Semi-Confined	$4.39	1.27
#4C	6	16-18	Hydraulic	Open-Bay/Semi-Confined	$3.12	1.61
#5A1-01	4	220-221	Hydraulic-4 Scows	Offshore	$7.34	3.60
#5A1-01	4	220-221	Hydraulic-3 Scows	Offshore	$7.98	3.91
#5A1-01	4	220-221	Hydraulic-2 Scows	Offshore	$8.43	4.13
#5A1-03	4	220-221	Clamshell-3 Scows	Offshore	$8.72	4.27
#5A1-03	4	220-221	Clamshell-2 Scows	Offshore	$7.77	3.81
#5A2	4	220-221	Hopper	Offshore	$25.21	12.36
#5A3	4	220-221	Hydraulic	Offshore (2 mi.)	$12.77	6.26
#5B1-01	6	233-234	Hydraulic-7 Scows	Offshore	$7.69	3.96
#5B1-01	6	233-234	Hydraulic-6 Scows	Offshore	$7.54	3.89
#5B1-01	6	233-234	Hydraulic-5 Scows	Offshore	$7.87	4.06
#5B1-01	6	233-234	Hydraulic-4 Scows	Offshore	$8.01	4.13
#5B1-01	6	233-234	Hydraulic-3 Scows	Offshore	$9.20	4.74
#5B1-01	6	233-234	Hydraulic-2 Scows	Offshore	$12.60	6.49
#5B1-02	6	233-234	Clamshell-4 Scows	Offshore	$7.46	3.85
#5B1-02	6	233-234	Clamshell-3 Scows	Offshore	$6.61	3.41
#5B1-02	6	233-234	Clamshell-2 Scows	Offshore	$7.77	4.01
#5B2	6	233-234	Hopper	Offshore	$31.53	16.25
#5B3	6	233-234	Hydraulic	Offshore (2 mi.)	$14.54	7.49
#5C1	4	10-13	Hopper	Offshore	$31.06	15.23
#5C1	5	14-15	Hopper	Offshore	$38.50	11.10
#5C1	6	16-18	Hopper	Offshore	$32.14	16.57
#5C2	5	14-15	Hopper	Offshore	$34.83	10.04
#5C2	6	16-18	Hopper	Offshore	$36.53	18.83
DMMP	1	1-3	Hydraulic	As per DMMP	$2.51	1.28
DMMP	2	4-5	Hydraulic	As per DMMP	$2.43	1.11
DMMP	3	6-9	Hydraulic	As per DMMP	$3.10	1.31
DMMP	4	10-13	Hydraulic	As per DMMP	$2.23	1.09
DMMP	5	14-15	Hydraulic	As per DMMP	$4.60	1.33
DMMP	6	16-18	Hydraulic	As per DMMP	$1.96	1.01

Offshore placement with a hopper dredge was the most expensive alternative with costs ranging from \$25.21 to \$38.50/cy. Offshore placement in general was several times current costs, ranging from \$5.62/cy to the \$38.50/cy noted above. Upland confined and upland thin layer were also relatively expensive, with \$/cy costs ranging from \$3.47 to \$18.10. The DMMP costs range from \$1.96 to \$4.60/cy.

Table 2-35 also gives the ratio of the cost of each alternative to the present practice. As can be seen, the ratio for the DMMP costs range between 1.01 to 1.33 times current cost, whereas the ratios for offshore with a hopper dredge range from 2.90 to 18.83 times current costs.

3.0 AFFECTED ENVIRONMENT

3.1 ENVIRONMENTAL SETTING

The Laguna Madre is a long, narrow, hypersaline lagoon extending from Corpus Christi Bay to the southern end of South Bay near the Rio Grande. Since the concerns of the ICT are with maintenance dredging and placement practices in the Laguna Madre, the study area for the FEIS will include from the JFK Causeway, that joins Flour Bluff to Padre Island, to the old Queen Isabella Causeway, that once joined Port Isabel to South Padre Island. Figure 1-1 depicts the northern, middle, and southern reaches, respectively, of the Laguna Madre study area. Descriptions and illustrations of Laguna Madre resources with respect to these three reaches will be presented throughout the FEIS. The coastline of this area extends across five Texas counties: Nueces, Kleberg, Kenedy, Willacy, and Cameron. The width of the Laguna Madre is typically 3 to 5 miles and approximately 9.3 miles at the widest location near South Padre Island (Hedgpeth, 1947). The natural depth throughout the Laguna Madre is less than 5 feet with the majority of the area being very shallow (Hedgpeth, 1947).

The Laguna Madre is subdivided into two basins, the ULM and the LLM, with the two being separated by the Saltillo Flats (Land Bridge). The USACE completed construction of the GIWW within the study area in 1949. Upon completion of the GIWW, the ULM and LLM, once separated by the Land Bridge, were permanently connected. The portion of the GIWW that connects the ULM and LLM is commonly referred to as the Land Cut.

Resources of a proposed study area are typically determined significant based on institutional, public, or technical considerations and the likelihood of the resource to be affected by one or more of the alternative plans being evaluated (USACE, 1995). The significant resources determined for the Laguna Madre were based on these criteria and the fact that the study area involves a highly unique and dynamic environment supporting recognized threatened and endangered species and many environmentally sensitive resources. Significant resources for this study are judged to include water quality; sediment quality; special aquatic habitat; finfish and shellfish resources; wildlife resources; threatened and endangered species; hazardous, toxic, and radioactive wastes; and cultural and socioeconomic resources.

3.1.1 Physiography

The Laguna Madre is subdivided physiographically into four distinct units: 1) the ULM, 2) the central exposed flats (Saltillo Flats), 3) Baffin Bay and its estuaries, and 4) the LLM. The Saltillo Flats, generally known as the Land Cut, is a subareal eolian feature approximately 21 miles long and 10 miles wide located in eastern Kenedy County between the southern extent of The Hole and the LLM. The Land Cut consists of an extensive area of sporadically inundated tidal flats which start approximately 10 miles south of the mouth of Baffin Bay and extends southward approximately 31 miles. The ULM extends northward from the Land Cut for approximately 40 miles, gradually widening to a maximum 3.5 miles where it joins Corpus Christi Bay at its northern extreme. A maximum depth of 10 feet is found in the vicinity near Baffin Bay, but the section is generally less than 5 feet deep. A small, spoon-shaped basin (10 miles long, 2 miles wide, and less than 6 feet deep) called The Hole is located between Baffin Bay and the Land Cut. Another significant feature of the ULM is the Flour Bluff area, found on the mainland shore stretching north of Baffin Bay. This area appears as a topographic high rising above the surrounding area (it is generally over 25 feet above mean sea level [MSL]). It is a part of the Ingleside Barrier Island of Pleistocene age, an ancient barrier island system which once extended as far south as the deltaic plain of the Rio Grande. Due to the semiarid climate south of Baffin Bay, vegetation cover could not develop to stabilize the barrier sand, thereby allowing wind action to spread it inland forming the present day eolian plain (Rusnak, 1960; Barnes, 1975).

The Baffin Bay system is considered a distinct physiographic unit from the rest of the Laguna Madre because it represents drowned stream valleys formed before the buildup of the Padre Island barrier chain. The Baffin Bay system consists of Baffin Bay, Alazan Bay, Cayo Del Grullo, and Cayo Del Infiernillo. The main body of Baffin Bay is approximately 14 miles long, a maximum of 4 miles wide and averages about 6 feet deep (Brown et al., 1977).

The LLM extends approximately 55 miles from the Land Cut at its northern extreme, to Brazos Santiago Pass and the Port of Brownsville Entrance Channel at its southern boundary. The LLM can be further subdivided into a northern and southern half. Mud flats which extend westward from Padre Island opposite the mouth of the Arroyo Colorado constrict the Lower Laguna to a minimum width of about 3 miles in that area. The northern-most basin, Red Fish Bay, is 30 miles long, has a maximum width of 6 miles and maximum depth of 10 feet. The southernmost basin is about 25 miles long and connects with the Gulf of Mexico through Brazos Santiago Pass. It reaches a maximum width of 7 miles and a maximum depth of over 6 feet.

From Port Mansfield south approximately 25 miles to Three Islands, the mainland shore is a delta-type, built up by flood outlets of the Lower Rio Grande Valley. These drainage floodways are the Arroyo Colorado and the Cayo Atascosa (both natural streams), and the manmade North Floodway. The North Floodway and the Arroyo Colorado connect with the Rio Grande River near Mission, Texas so their drainageways not only carry excess rainwater and irrigation water of the Lower Valley, but also carry flood waters from the Rio Grande. The Cayo Atascosa also carries drainage and irrigation water, but impoundments located in the LANWR greatly limit the waters which can reach the Laguna Madre. Because of the semiarid nature of the region, deposition in the delta area is intermittent, and the area has become, in part, erosional. An artificially maintained cutoff channel of the Arroyo Colorado, 10 feet deep and 125 feet wide, serves waterborne traffic going to the Port of Harlingen from the GIWW. This cutoff channel is located south of the delta area and further inhibits deltaic growth by diverting drainage water (Brown et al., 1980).

3.1.2 Geology

The nature and distribution of the land and water features along the Laguna Madre are a result of several active, natural geologic processes, e.g., longshore drift, beach swash, wind deflation and deposition, tidal currents, wind generated waves and currents, delta outbuilding, and river point-bar and flood deposition. The coastal zone is entirely underlain by sedimentary deposits that originated in ancient but similar coastal systems (Brown et al., 1976, 1977, and 1980). Sediment distribution for the bay-estuary-lagoon system in the project area consists chiefly of terrigenous clastics (i.e., sands and gravels). Clean quartz sands can be found in some dredged material placement areas, along parts of the mainland shoreline, and in the wind-tidal flats areas. Muddy sands occur adjacent to dredged material placement mounds, in the shallow bay-margin area next to the mainland shoreline, and at the edge of the wind-tidal flats. Muddy sand distribution is not depth controlled, rather it is related to hurricane washovers, dredging activities, and reworking of relict sediment (McGowan and Morton, 1979).

3.1.3 Hydrology

Hydrology of the Laguna Madre is influenced primarily by climatological conditions such as rainfall and wind, to a lesser degree from tides and openings to the Gulf of Mexico, and, to a lesser extent, on freshwater inflow. The creation of the GIWW and enhanced water circulation also play a role in the hydrology of the system. Due to the unique hydrological characteristics present in the Laguna Madre, separate reaches have been included to specifically address water quality, water exchange and inflows, and salinity.

3.1.4 Climate

The climatic characteristics of the Laguna Madre are subdivided near Baffin Bay. Typically, precipitation and evaporation are fairly balanced to the north of Baffin Bay whereas evaporation tends to dominate precipitation in areas below Baffin Bay (Hedgpeth, 1947). Rainfall along the south Texas coast is typically seasonally distributed with an average annual rainfall in counties bordering the Laguna Madre of approximately 2 feet (Brown et al., 1977). The wind also appears to be a major factor in the amount of water exchange that occurs in both the ULM and LLM. Coastal Impact Monitoring Program (1995) describes the example of strong southeasterly winds prevalent for much of the year tending to pull more saline water from the southern portion of the ULM through the reach, whereas northerly winds prevalent in the winter tend to pull less saline water from Corpus Christi Bay into the ULM.

3.2 WATER QUALITY

The quality of water within the project area has generally been characterized as good to moderate with some special studies identifying areas of concern. Contributing factors affecting the overall water quality in the Laguna Madre center around a wide range of physical, chemical, and biological processes often working in unison to create a highly dynamic environment.

3.2.1 Water Exchange and Inflows

The construction of the GIWW increased circulation within the Laguna Madre and exchange with the Gulf of Mexico. Water exchange between the ULM and the Gulf of Mexico is primarily attributed to Corpus Christi Bay while within the LLM, the Brazos Santiago Pass and Port Mansfield Channel serve as permanent exchange points with the Gulf of Mexico. The Land Cut allows some continual water exchange between the ULM and LLM. The western Gulf of Mexico is a microtidal region, which causes the Laguna Madre tides to be extremely small. Water level fluctuation depends more on the meteorological conditions (wind speed and direction, barometric pressure) than the astronomical forcing in much of the lagoon (Gill et al., 1995). The low tide range is attributed to the small number of tidal inlets into the Laguna Madre, the long distances from the inlets to the center of the Laguna Madre, and the large area of the Laguna Madre (Morton et al., 1998). A combination of these factors tend to reduce the impact that oceanic tides have on the Laguna Madre.

The freshwater inflow to the ULM is essentially limited to intermittent streams draining into Baffin Bay, while the North Floodway (drains into the Laguna Madre near the northern end of PA 222), Arroyo Colorado, and Cayo Atascosa (drains into the Arroyo Colorado) serve as the main sources of freshwater inflow for the LLM (Coastal Impact Monitoring Program, 1995). Although limited compared with other bays and estuaries, the freshwater inflows to the Laguna Madre serve the same important functions. One such function is to blend with the Laguna Madre's saltier water to provide a range of salt concentrations. In general, the majority of organisms that live in estuarine systems need water with different ranges of salinity at varying stages of their life cycles. The Texas Coastal Management Program (TCMP, 1996) reports that as many as 98 percent of important marine species rely on estuaries during some stage of their life cycle. An additional value freshwater inflow contributes is the nutrient inputs which are essential to the total productivity of the Laguna Madre. Nutrients (nitrogen, phosphorus, and decomposing organic matter) are typically deposited into the Laguna Madre through surface runoff. The entire food web is dependant on the utilization of these nutrients for primary production by microscopic plankton and utilization by larger plants for growth. The primary productivity sustains the food chain while the larger plants provide food and breeding, hatching, resting, and protective areas for many forms of aquatic and terrestrial animals (Coastal Bend Bays Plan (CBBP), 1998). Another important factor is that freshwater inflows often bring sediments into the Laguna Madre. Sediment inputs help create muddy deltas and sandy barrier islands. Without the replenishment of sediments into estuarine systems, accelerated erosion of coastal uplands and destruction of existing wetlands might occur.

3.2.2 Salinity

The Laguna Madre of Texas is one of only three large hypersaline lagoons in the world (Hedgpeth, 1947). A complex interaction of factors including tidal activity, wind, water depth, evaporation, and freshwater inflow largely regulate the salinity of the Laguna Madre (Coastal Impact Monitoring Program, 1995). As previously described, the Laguna Madre is relatively isolated from the Gulf of Mexico by a continuous barrier island with only a few water exchange areas with the Gulf of Mexico existing, except under extremely high tidal conditions, and only the Land Cut connecting the ULM and LLM. Due to the shallow water depths throughout the Laguna Madre, Warshaw (1975) notes that broad areas are often left uncovered by water at low tide or during strong winds. During these instances, salt deposits along these tidal flats are left as a result of evaporation and may be redissolved at high tide or during times of heavy runoff (Warshaw, 1975). In addition, the limited amount of freshwater inflow to both the ULM and LLM as mentioned above, contributes greatly to the salinity regime of the Laguna Madre. It has also been documented that the construction of the GIWW increased circulation within the Laguna Madre and water exchange with the Gulf of Mexico (Warshaw, 1975).

Prior to the GIWW, salinities were often greater than 60 parts per thousand (ppt) (Quammen and Onuf, 1993). Warshaw (1975) states that in the 3 years prior to the construction of the GIWW, salinities frequently exceeded 70 ppt. Quammen and Onuf (1993) report that increased exchange with the Gulf of Mexico resulting from channel dredging, increased precipitation, and increased flow from the Arroyo Colorado and North Floodway have aided in the decrease of hypersaline conditions in the Laguna Madre. The increase of agricultural drainage is documented as the principal cause of increasing flows in the Arroyo Colorado and North Floodway (Quammen and Onuf, 1993). Allison (1987) supports the concept that increases in the amount of freshwater that reaches the LLM was due to agricultural runoff and the extensive construction of irrigation and floodway systems. Additional factors contributing to salinity changes include sharp declines in association with precipitation during tropical storms and hurricanes. Other more temporal declines in salinity reflect floodwaters entering the Laguna Madre via streams feeding Baffin Bay in the ULM and the North Floodway and Arroyo Colorado in the LLM.

3.2.3 Water Chemistry

When considering the size of the defined study area, the actual amount of water quality data, excluding standard parameter information, is small in comparison to other areas along the Texas coast. However, in comparison to other areas along the Texas coast, the potential sources for contamination within the Laguna Madre are limited as well. The TCEQ has designated water uses for the Laguna Madre to include contact recreation, high to exceptional quality aquatic habitat, and oyster waters (TNRCC, 2000).

High water temperatures have not been reported as a problem in the Laguna Madre (Warshaw, 1975; Bowles, 1983; Webster, 1986). However, low or sudden drops in water temperatures during excessively cold and prolonged northers have done catastrophic damage to marine life in the Laguna Madre (Breuer, 1962). The extreme cold events have caused some extensive fish kills and have been known to kill black mangroves (*Avicennia germinans*) in the LLM (Lonard and Judd, 1985, 1991). As with water temperature, DO levels reported throughout the majority of the study area have been suitable for the support of aquatic life (Warshaw, 1975; Bowles, 1983; Webster, 1986). Occasionally during the warmer months, problems associated with low DO will occur at the mouth of the Arroyo Colorado and Port Mansfield/GIWW intersection (Coastal Impact Monitoring Program, 1995).

As previously discussed, nutrients are a vital part of any estuarine system. The EPA has characterized nitrogen and phosphorus in the Laguna Madre based on the Dissolved Concentration Potential (DCP) concept. The DCP is a function of freshwater flushing time (flushing ability) and estuarine volume (dilution ability) (EPA, 1998). The Laguna Madre is estimated to have a medium susceptibility for concentrating dissolved substances. This DCP combined with the existing nitrogen (total kjeldahl nitrogen) loading, results in a predicted concentration within the medium range for nitrogen while the DCP combined with the existing phosphorus loading, results in a predicted concentration in the high range for phosphorus (EPA, 1998). NOAA/EPA (1989) report that within the Laguna Madre, concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings.

Historically, Warshaw (1975) reported that nutrient concentrations were considerably higher where the Arroyo Colorado intersects the GIWW than at other stations in the LLM. The phosphate concentrations at this confluence were also about three times higher than at other stations in the LLM (Warshaw, 1975). The markedly higher concentrations of total nitrogen, total phosphorus, and total organic carbon (TOC) in the Arroyo Colorado and North Floodway most likely reflect the agricultural and urban uses prevalent in those watersheds. TNRCC (1994) reports that 16 percent of the Laguna Madre is restricted for oyster harvesting due to actual or potential fecal coliform contamination.

Warshaw (1975) reported that the concentrations of heavy metals and other contaminants are low in the water column, and probably constitute baseline levels for the Laguna Madre. The one area of concern mentioned was at the mouth of the Arroyo Colorado where pesticides have historically been reported as a problem (Warshaw, 1975). More recent studies have demonstrated that only a few areas in the ULM and LLM have reported higher levels of certain compounds within the water column. Ward and Armstrong (1997) reported that elevated metal concentrations were found in the vicinity of the Bird Islands in the ULM, although no cause was established. Davis et al. (1996) reported that screening levels were exceeded for arsenic in water near the mouth of the Arroyo Colorado and in toxicity testing of water, inland silverside (*Menidia beryllina*) growth was significantly affected in water, although no likely causative agent was apparent. In addition, screening levels were exceeded for arsenic and silver in water near the mouth of the North Floodway. In toxicity testing of water from the same station, inland silverside growth was significantly reduced and silver was suggested as the potential causative agent (Davis et al., 1996). Davis et al. (1996) concluded that these two stations exhibited only slight impacts from toxic chemicals and that they were not impairing the designated high aquatic life use of the Laguna Madre.

In a recent study conducted for the EPA, chemical analyses were conducted on water, elutriate, and sediment samples from 26 stations in the GIWW throughout the Laguna Madre and on samples collected at reference stations (LWA, 1998; EH&A, 1998a). In all water and elutriate samples, arsenic, barium, cadmium, chromium, copper, lead, zinc, and TPH were detected (EH&A, 1998a). There were no pesticides, polychlorinated biphenyls (PCBs), or PAHs detected in any of the water or elutriate samples. The results of the chemical analyses on the water and elutriate samples indicate that, of the above mentioned detected chemicals, only concentrations of copper in elutriate samples exceeded the WQS indicating a potential cause for concern (EH&A, 1998a). Therefore, an analysis of the dilution required to achieve the WQS was conducted and indicated that the LPC for the water column is not exceeded with regards to the concentration of copper (EH&A, 1998a).

3.2.4 Brown Tide

A recurring water quality concern has been the brown tide (DeYoe et al., 1997; Whitledge, 1993). As previously mentioned, the brown tide organism was determined to be *Aureoumbra lagunensis*, a planktonic algae that cannot use nitrate but can use the ammonium ion for growth (DeYoe et al., 1997). Two freezes in December 1989 caused the death of an estimated 965,000 fish (Buskey et al., 1996), which combined with a dramatic decrease in benthic bioamass, likely from increasing salinity and the cold temperatures, could have released as much as 69 micromoles (μM) of ammonium (DeYoe and Suttle, 1994). Field sampling detected up to 27 µM ammonium in Baffin Bay (Whitledge, 1993). The occurrence of brown tide was noted in January 1990 and subsequently spread rapidly throughout Baffin Bay and the ULM persisting until October 1997 (Whitledge, 1993; Tunnell and Judd, 2002). Although initially the prevailing southeasterly winds in summer and fall prevented transportation of the brown tide into the LLM, the onset of winter and the passage of several cold fronts with north winds enabled the brown tide to enter the LLM in late 1990 (Stockwell et al., 1993). Whitledge (1993) reports that this brown tide phenomenon has been present at varying times in history and continues to be a recurring problem.

Buskey et al. (1996) estimate that the brown tide has caused a recent loss of approximately 2,470 acres of seagrass coverage in the ULM and has also contributed to impacts such as decreased abundance, biomass, and diversity of benthic fauna and reduced larval fish populations. Stockwell (1993) suggests that the persistent brown tide has temporarily changed the phytoplankton/seagrass production ratio and altered nutrient cycles within the Laguna Madre. Barrera et al. (1995) report that under normal conditions, turbidity is minimal and seagrass meadows are extensive in the Laguna Madre, but the persisting brown tide bloom had caused serious problems to the seagrasses of the Laguna Madre. Bloom conditions continue to persist in some areas of the system during certain times of the year (Tunnell and Judd, 2002). Though the concentration of brown tide organisms decreased in 1998, other algal species are contributing to a bloom (Dunton, pers. com.).

3.3 SEDIMENT QUALITY

Sedimentation in the Laguna Madre is caused by sediment input from outside sources (i.e., Arroyo Colorado) and the movement of deposits in the lagoon from one area to another due to physical disturbance. To varying degrees, both processes involve the settling of particles from the water column. The materials present in the sediment can exert an important influence upon the water quality in the surrounding area. Warshaw (1975) describes wind-induced water movements, ship traffic, and dredging activities as some of the processes that can cause mixing and transfer of materials from the sediment to the water.

Warshaw (1975) documented that sediment in the Laguna Madre contains a relatively high proportion of sand and a low proportion of clay, compared with sediments in other Texas bays. Recent sediment investigations (LWA, 1998; EH&A, 1998a; Teeter et al., 2003) have shown that sediments from study locations within the GIWW are primarily silts and fine sands, with the finer sediments being located in the lower half of the ULM and the upper half of the LLM, bracketing the Land Cut. During an intensive benthic macrofaunal analysis of dredged material placement areas in the Laguna Madre, sediment texture was also analyzed (EH&A, 1998b). The sediment classification for the placement areas and reference sites identified four major categories: sand, silty sand, silty-clayey sand, and sandy-clayey silt (EH&A, 1998b). These sediment types were generally associated with particular placement areas with sand and silty-sand sediments most prevalent in the ULM and mixed sediment (typically, silty-clayey sand) prevalent in the LLM. Overall, the sediment texture within the placement areas was similar, in most cases, to the texture exhibited at nearby reference stations (EH&A, 1998b). In a few instances, a relatively low percent sand was observed within placement areas, indicating that past placement practices may have resulted in changes from predominantly sand habitats to mostly silt-clay habitats (EH&A, 1998b). In contrast, occasionally the reference stations exhibited finer sediments than the placement areas.

Warshaw (1975) reported that the sediment quality within the Laguna Madre was very good, as expected, since no significant industrial discharges were present in the Laguna Madre and barge traffic on the GIWW was light at the time. Today, conditions within the Laguna Madre study area are, for the most part, very consistent with Warshaw's findings, since no significant discharges have been added and waterborne traffic is still moderate.

Recent sediment investigations report that most sediments throughout the ULM have low levels of trace metal contamination, except for certain areas (Barrera et al., 1995). These areas in the ULM involved relatively elevated levels of arsenic, boron, cadmium, copper, lead, mercury and zinc. Ward and Armstrong (1997) have also documented elevated metal concentrations around the Bird Islands in the ULM, but these were not GIWW samples. Other recent sediment investigations have demonstrated that, in general, sediment with finer particles tended to have higher trace metal concentrations, sulfides, and ammonia (EH&A, 1998a). TPH, phenols, PCBs, and pesticides were below detection limits in all sediment samples collected in a 1997 sediment collection effort spanning the entire Laguna Madre (EH&A, 1998a). During that same study, it was reported that detected metals in sediment samples were not noticeably different from reference samples, with the exception of four (2 each) extremely high (possibly aberrant) values for arsenic and cadmium (EH&A, 1998a).

As with water quality parameters, the mouth of the Arroyo Colorado has been documented to have higher levels of some pesticides than other areas of the Laguna Madre (Warshaw, 1975; Davis et al., 1996). This is not unusual since the Arroyo Colorado transports a substantial amount of agricultural runoff and treated sewage. As previously mentioned, Davis et al. (1996) reports that only slight impairment was found near the mouth of the North Floodway and Arroyo Colorado, and that toxic chemicals found did not affect the high quality aquatic life use criteria set forth for the Laguna Madre. Recent USACE data from the Channel to Harlingen show no elevated levels of organochlorine pesticides.

3.3.1 Toxicity Testing

There is very little information concerning toxicity testing in the Laguna Madre. As part of a special study authorized by the USACE on the advice of the ICT, solid phase bioassays and bioaccumulation studies were conducted on sediment from six test stations, on Reference Control Sediment, and on a True Control (LWA, 1998; EH&A, 1998a). The survival of organisms exposed to test sediments in the solid phase bioassays was not significantly different from survival of organisms exposed to the solid phase of the reference control, except for one station in the LLM. Based on the examination of numerous factors, as required by the tiered approach in EPA/USACE (1991), significant ecological impacts would not be indicated by the results of the bioaccumulation study (EH&A, 1998a).

An earlier study involved toxicity testing of sediment collected near the mouths of the Arroyo Colorado and North Floodway (Davis et al., 1996). The test organisms were not significantly affected in the toxicity tests conducted with sediment from near the mouth of the Arroyo Colorado (Davis et al., 1996). In toxicity testing of sediment taken near the mouth of the North Floodway, the Mysid (*Mysidopsis* [now *Americamysis*] *bahia*) survival was significantly reduced and inland silverside growth may also have been affected, but duplicate samples produced conflicting results (Davis et al., 1996).

In 1986, a series of solid phase bioassays and a bioaccumulation study was conducted on sediment collected from Corpus Christi Bay to the Land Bridge (EH&A, 1987). The purpose of the study was to determine the potential environmental impact of the proposed bay placement of maintenance material to be dredged in order to maintain the GIWW along the reach. There was no significant difference among mean survival of organisms exposed to the solid phase of sediments from the test stations and the reference control and, therefore, there was no indication of bioaccumulation of any parameter in tissue for any station (EH&A, 1987). The final conclusions were that reasonable assurance was provided that no significant undesirable impacts would occur upon placement of the sediments tested.

3.3.2 Sediment Budget

An important aspect in evaluating the effects of maintenance dredging in the Laguna Madre is to examine the sediment budget of the system. A special study was conducted at the request of the ICT to specifically address sediment budget issues. The study determined that the "average annual volume of new sediment delivered to Laguna Madre . . . is . . . 969,600 m^3" (Morton et al., 1998). Of this new sediment, Morton et al. (1998) determined that 44,320 m^3 makes its way into the GIWW. Over the past 45 years, the average annual maintenance dredging has been 1,659,429 m^3 (Morton et al., 1998). Therefore, Morton et al. (1998) concluded that reworking of dredged material accounts for most (97.3%) of the accumulation of maintenance material in the GIWW through the Laguna Madre. Later refinements of maintenance dredging records indicate that annual maintenance dredging is 1,516,083 m^3, slightly modifying the percentage of reworked sediment to 97.1 percent.

One important item that resulted from the analysis of sediment inputs in the Laguna Madre is that, when the average sedimentation rate is compared with average sea level rise on the south Texas coast, it is evident that the Laguna Madre is not filling up, but is slowly being submerged.

As previously mentioned, wind is a major physical agent affecting the south Texas coast. Over both geological and historical time scales, the wind has proved to be a highly efficient sorter and transporter of sediment and it has been responsible for supplying large volumes of sediment to Laguna Madre (Morton et al., 1998). Morton et al. (1998) adds that due to the drought period and exposed sediment following the GIWW construction, the wind was the primary erosional factor. Today, water serves as the main force in eroding the placement areas and reworking the dredged material, especially for maintenance material (Morton et al., 1998).

3.4 COASTAL COMMUNITY TYPES

The Laguna Madre ecosystem provides essential nursery habitat for numerous commercially and recreationally important estuarine-dependent fish and shellfish species, as well as providing habitat for marine mammals, reptiles, resident birds, wintering water fowl, shorebirds, and other avian species. This section describes the main types of habitat present in the Laguna Madre system.

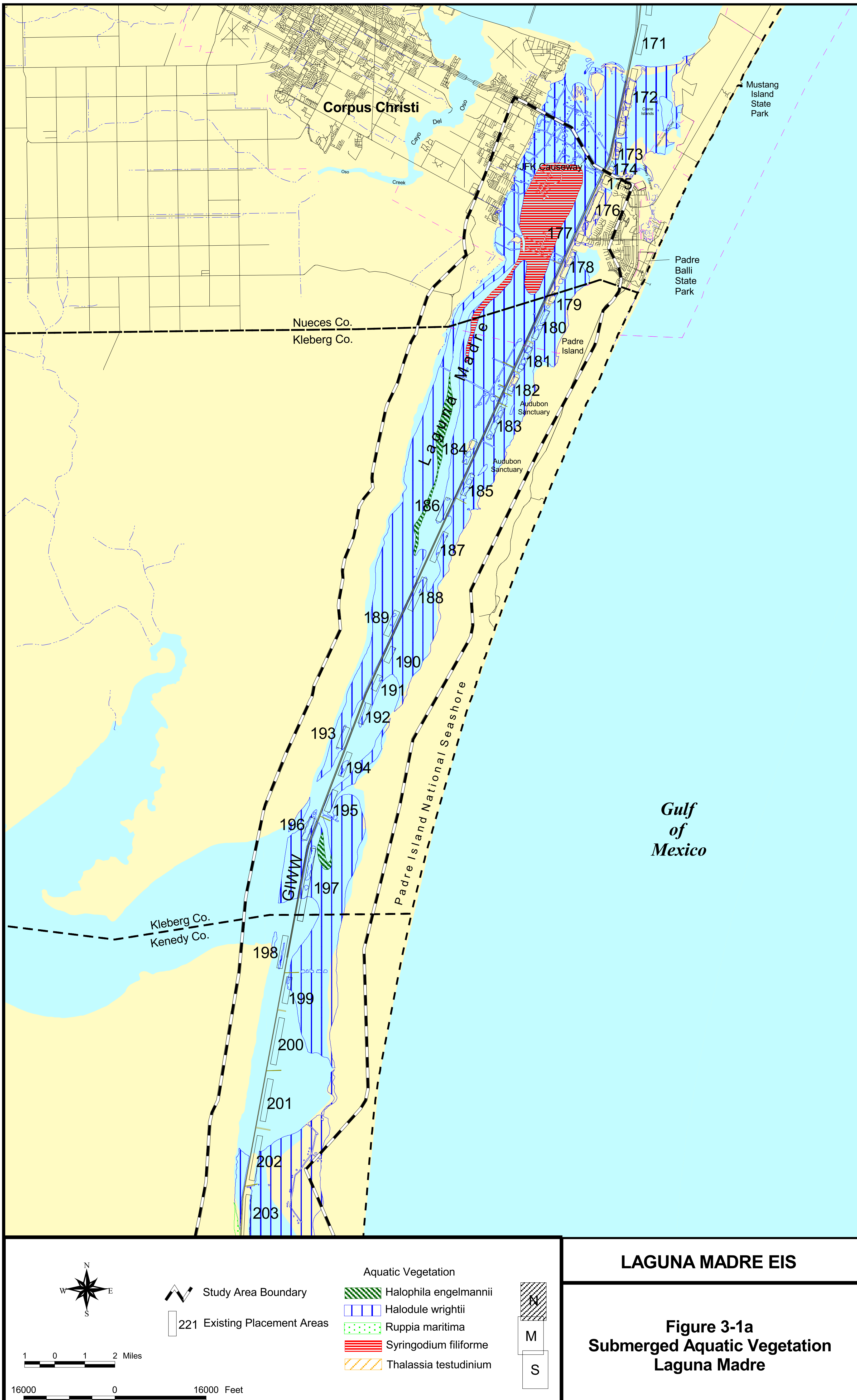
3.4.1 Submerged Aquatic Vegetation (SAV)

The shallow depth of the Laguna Madre coupled with the nutrient and suspended particle concentrations present in the system provide for extensive coverage of submerged aquatic vegetation (SAV), primarily seagrasses (Pulich, 1980). However, prior to the construction of the GIWW, extreme hypersalinity excluded the growth of SAV from much of the Laguna Madre (Quammen and Onuf, 1993). Figure 3-1 depicts SAV coverages for the defined project area as reported by Dr. Chris Onuf from his 1998 survey of the Laguna Madre, conducted for a Status and Trends report for the Gulf of Mexico Program. These SAV communities generate high primary productivity and provide refuge for numerous organisms. Five SAV genera (*Halodule*, *Thalassia*, *Syringodium*, *Halophila*, and *Ruppia*) occur in Texas (Pulich, 1998). All five genera are found in the Laguna Madre with the subtropical shoalgrass being the most abundant SAV species, maintaining extensive beds in the ULM (Pulich, 1998). The tropical species, turtlegrass (*Thalassia testudinum*) and manateegrass (*Syringodium filiforme*), are most abundant in the LLM. According to Pulich (1998), the Laguna Madre system has undergone dramatic changes in SAV distribution since the 1950s.

The ULM contains all of the above mentioned SAV species. An analysis of SAV trends conducted by FWS (Quammen and Onuf, 1993) documents major changes in SAV in the Laguna Madre. This analysis was based on surveys in 1988 and a review of historical data (McMahan, 1965–67; Merkord, 1978). The study showed a 66 percent increase in SAV, primarily shoalgrass but also clovergrass (*Halophila engelmannii*) and widgeongrass (*Ruppia maritima*), from 1967 to 1976 and a 29 percent total increase from 1976 to 1988 (Quammen and Onuf, 1993). However, from 1988 to 1994, a 3.8 percent decrease in shoalgrass occurred (Pulich, 1998), most likely due to a persisting brown tide (see Section 3.2.4). Pulich (1998) also reports that some patches of manateegrass have recently become established in the ULM and are continuing to spread.

The LLM contains all five SAV taxa prevalent along the Texas coast. Since the 1970s, Quammen and Onuf (1993) noted a major divergence evident in the dynamics of the LLM. It was determined that between 1967 and 1988, shoalgrass decreased 60 percent, while mostly manateegrass (and some turtlegrass) increased by 270 percent (Quammen and Onuf, 1993). In addition, the overall bare unvegetated area in the LLM increased 280 percent (Quammen and Onuf, 1993). The bare areas appear to be confined to the deeper parts of the LLM.

Quammen and Onuf (1993) have suggested that the shifts in SAV cover in the Laguna Madre are likely attributed to changes in the salinity regimes caused primarily by changes in bay/Gulf interchange via channels (including ship channels and the GIWW), increased turbidity caused by maintenance dredging of the GIWW, and eutrophication resulting from nutrient inputs. Other researchers have suggested that events responsible for large freshwater additions and the brown tide have played a major role in the alteration of SAV communities (Brown et al., 1976; Buskey et al., 1996; Stockwell, 1993; Barrera et al., 1995; Pulich, 1998).



LAGUNA MADRE EIS

Figure 3-1a
Submerged Aquatic Vegetation
Laguna Madre

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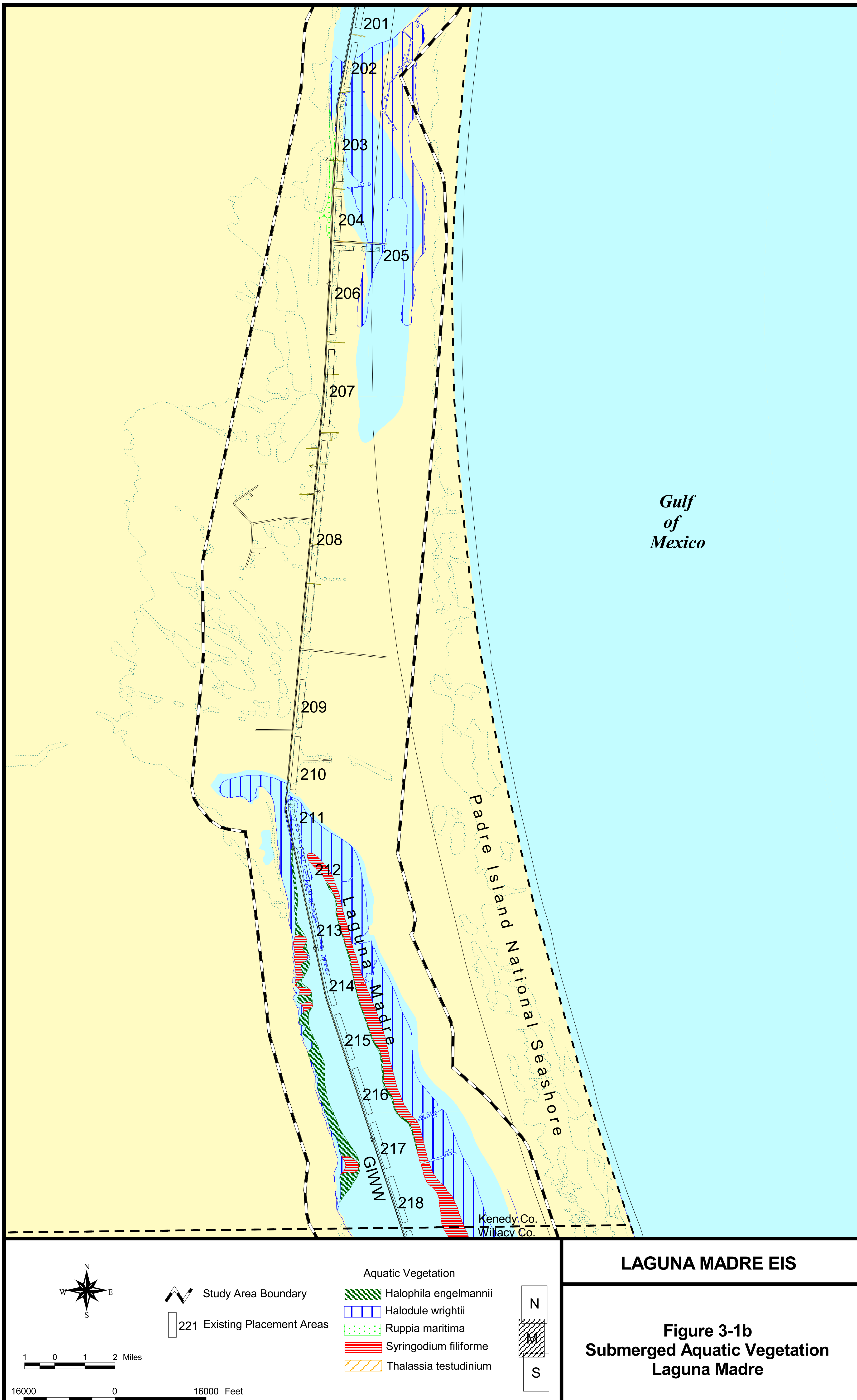

LAGUNA MADRE EIS

Figure 3-1b
Submerged Aquatic Vegetation
Laguna Madre

File: N:\440319\arcview\seagrass.apr (Seagrass_m_Layout)

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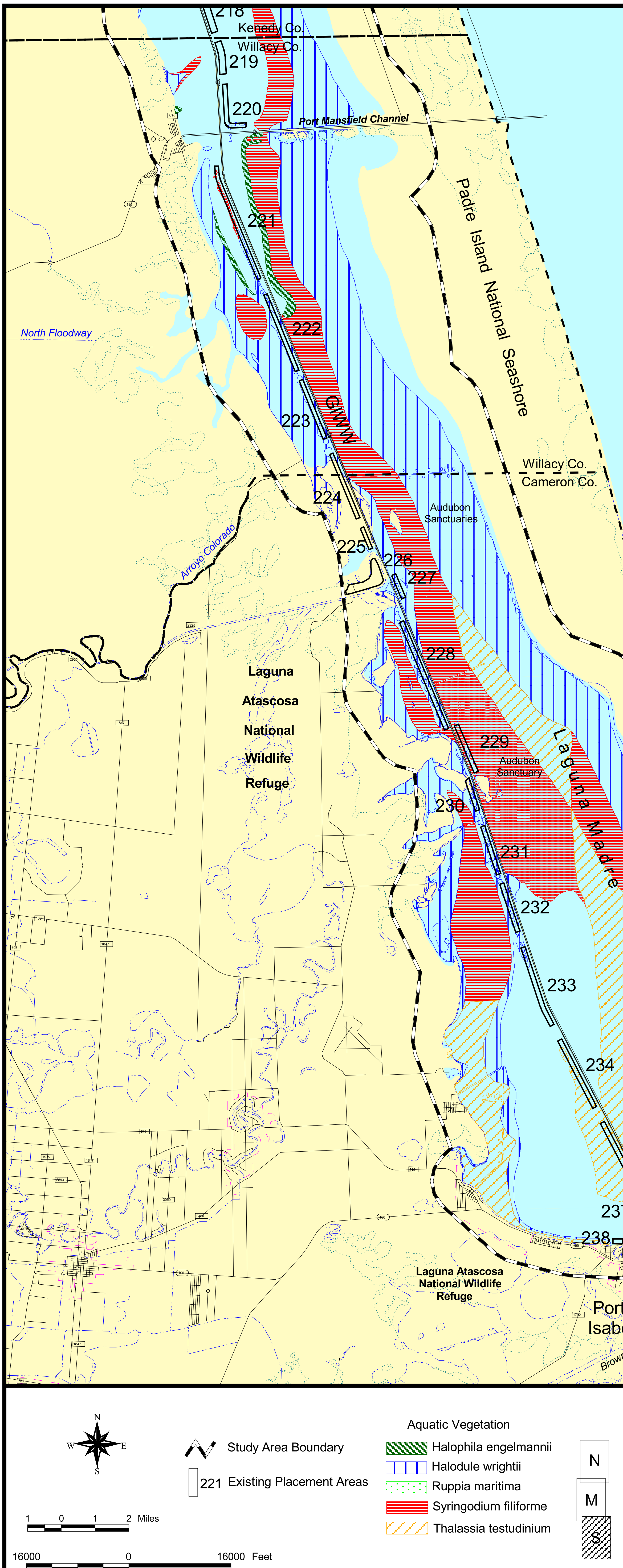

LAGUNA MADRE EIS

Figure 3-1c
Submerged Aquatic Vegetation
Laguna Madre

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3.4.2 Coastal Wetlands

The coastal wetlands of the Laguna Madre play an important role in sustaining the health and abundance of life within this ecosystem. Coastal wetlands are distinct areas between terrestrial and aquatic systems where the water table is at or near the surface or the land is covered by shallow water with emergent vegetation. They are extremely important natural resources that provide essential habitat for fish, shellfish and other wildlife (McHugh, 1967; Tunnell and Judd, 2002). Coastal wetlands also serve to filter and process agricultural runoff and buffer coastal areas against storm and wave damage (White and Paine, 1992). The broad, level, coastal lowlands often support landscape mosaics of several community types that intergrade. These communities include low and high salt and brackish marshes, salt prairies, vegetated and nonvegetated flats.

The terms low and high in reference to marshes indicates relatively wetter (low) and drier (high) soil conditions in these plant communities. This generally correlates to slope position or relative elevation (i.e., the high salt marsh is upslope from the adjacent low salt marsh). The low salt marsh corresponds to the Smooth Cordgrass Series and Saltgrass-Cordgrass Series, and the high salt marsh corresponds to the Glasswort-Saltwort Series as described by the Texas Natural Heritage Program (TNHP, 1993). The Smooth Cordgrass Series (*Spartina alterniflora*) is restricted to areas along the coast that are subject to daily tidal inundation. Associated species may include black rush (*Juncus romerianus*), coastal saltgrass (*Distichlis spicata*), big cordgrass (*Spartina cynosuroides*) and marshhay cordgrass (*Spartina patens*). In contrast to the upper Texas coast, there is only a very small percentage of smooth cordgrass (*Spartina alterniflora*) associated with the low salt marshes of the Laguna Madre and the Coastal Bend. Other common plant species include saltwort (*Batis maritima*), coastal saltgrass, and seashore dropseed (*Sporobolus virginicus*). The Saltgrass-Cordgrass Series (*Distichlis spicata-Spartina* spp.) is a salt or brackish marsh community that forms along the Gulf Coast. These two species can form nearly pure stands, but smooth cordgrass, marshhay cordgrass, species of *Paspalum*, seashore dropseed, and lovegrass (*Eragrostis* sp.) may be present. High salt marsh corresponds to the TNHP Glasswort-Saltwort Series (*Salicornia* spp. – *Batis maritima*). This plant community forms on alternately wet and dry saline soils, commonly on wind tidal flats. Associated species include shoregrass (*Monanthochloe littoralis*), camphor daisy (*Machaeranthera phyllocephala*), bushy sea ox-eye (*Borrichia frutescens*), seepweed (*Suaeda* spp.), sea purslane (*Sesuvium portulacastrum*), and seashore dropseed.

Salt prairie is a common term for the Gulf Cordgrass Series (*Spartina spartinae*), a transitional area including wetlands and nonwetlands (TNHP, 1993). Salinity also varies and species composition may include sedges (*Carex* spp.), flatsedges (*Cyperus* spp.), switchgrass (*Panicum virgatum*), and bushy bluestem (*Andropogon glomeratus*). It generally occurs between the upland grasslands and the coastal marshes (Diamond and Smeins, 1984).

The estuarine intertidal scrub-shrub category describes coastal wetlands dominated by woody vegetation and periodically flooded by tidal waters. Examples of estuarine intertidal scrub-shrub species in the study area include the black mangrove and big leaf sumpweed (*Iva frutescens*).

3.4.3 Tidal Flats (including Algal Flats)

The estuarine intertidal unconsolidated shore includes coastal wetlands periodically flooded by tidal waters and with less than 30 percent areal coverage by vegetation. This includes sandbars, mud flats, and other nonvegetated or sparsely vegetated habitats called salt flats. Sparse vegetation of salt flats may include glassworts, saltwort, and shoregrass. These tidal flats serve as valuable feeding grounds for coastal shorebirds, fish, and invertebrates. There are extensive sandflats occurring in the LLM. Overall, the Laguna Madre estuary contains 14 percent of the nation's tidal flats (TCMP, 1996).

Habitat consisting mostly of sand flats dominated by algal beds or blue-green algal mats and periodically flooded by astronomic or wind tides are also included in this category. In the south, low annual rainfall and very little freshwater inflow result in the creation of vast areas of algal flats (wind-tidal flats) with little to no emergent salt marsh vegetation (Barrera et al., 1995). Although wind-tidal flats are found throughout the Laguna Madre and occupy in excess of 50 percent of the lagoon area, the most extensive flats encompass the Land Bridge area (LWA, 1998a). Hedgpeth (1967) reported that flats in the Laguna Madre are covered with algal mat communities consisting mostly of the blue-green algae *(Lyngbya confervoides)*.

3.4.4 Open-Water/Reef Habitat

Open-water areas are distributed throughout the Laguna Madre with the larger areas located in the southern portions of the lagoon. In the Laguna Madre, open-bay bottom habitat covers approximately 186 square miles (76 square miles in Baffin Bay, 36 square miles in the ULM, 73 square miles in the LLM) (Tunnell and Judd, 2002). The open-bay bottom habitat in the LLM increased by 280 percent from 1967 to 1988, whereas in the ULM during that same period it decreased significantly as SAV cover increased by 110 percent (Quammen and Onuf, 1993). These open-water areas have been shown to support communities of benthic organisms and corresponding fisheries populations.

Several naturally occurring hard-substrate habitats occur in the Laguna Madre system. Reefs of the Eastern oyster (*Crassostrea virginica*) are present in some areas of the Laguna Madre and provide ecologically important functions within the estuary. The only living oyster reefs in the Laguna Madre are found in South Bay in the southernmost LLM. These oysters have adapted to the hypersaline conditions in the Laguna Madre and research has shown that they are genetically divergent from oysters inhabiting other parts of the Texas coast (Tunnel and Judd, 2002). Although oysters can be commercially harvested, very little commercial oyster harvesting takes place in the Laguna Madre.

A second type of reef environment present in the Laguna Madre are serpulid reefs. Serpulids are polychaetes (segmented marine worms) that build calcareous external tubes forming reef rock structures. These skeletal remnants are indicative of a less saline environment in the past (Tunnell and Judd, 2002). Serpulid reefs provide habitat for numerous species of crustaceans, mollusks, and polychaetes and are located across the mouth of Baffin and Alazan bays and along the bay margins (TCMP, 1996; Tunnell and Judd, 2002). Live serpulid polychaetes have been observed recently on the reefs, although in the hypersaline conditions they no longer appear to be building reef structure (Cole, 1981; Hardegree, 1997).

Another type of natural hard substrate habitat is beach rock (coquina) outcrops which occur from Baffin Bay at Penascal Point for a distance of about 6 miles south along the mainland shore (Prouty, 1996). These coquina outcrops represent the only lithified bedrock exposure along the South Texas coast (Tunnell and Judd, 2002). It forms part of a shallow sill across the mouth of Baffin Bay which, in the past, is thought to have restricted water circulation and caused increased salinities in the ULM prior to dredging of the GIWW and the Baffin Bay Channel (Rusnak, 1960; Collier and Hedgpeth, 1950).

3.4.5 Coastal Shore Areas/Beaches/Sand Dunes

The coastal shore areas function primarily as buffers protecting upland habitats from erosion and storm damage and adjacent marshes and waterways from water quality problems (TCMP, 1996). A variety of birds occur on coastal shores of the Laguna Madre: cranes, rails, coots, gallinules, and other groups can be found on the shorelines and in fringing marshes (Britton and Morton, 1989). Fiddler and hermit crabs are common along the bay-estuary-lagoon shorelines (TCMP, 1996).

Beaches along the south Texas coastline are dynamic habitats subject to a variety of environmental influences, such as wind and wave action, salt spray, high temperature, and moisture stress. The harsh conditions associated with the beach/dune system support a relatively small number of adapted animals and plants. Sand dunes help absorb the impacts of storm surges and high waves and also serve to slow the intrusion of water inland. In addition, dunes store sand that helps deter shoreline erosion and replenish eroded beaches after storms. The dune complexes are of two types, primary and secondary, which support two plant communities. The primary dunes, located immediately landward of the beach, are taller and offer more protection from wind and hurricane storm surge than the secondary dunes, which are landward of the primary dunes and are shorter and more densely vegetated. On the barrier islands of the Laguna Madre, typical plant species of the primary dunes include sea oats (*Uniola paniculata*), bitter panicum (*Panicum amarum*), Gulf croton (*Croton punctatus*), beach morning glory (*Ipomea pes-caprae* var. *emarginata*), and fiddleleaf morning glory (*Ipomea stolonifera*). Secondary dune species include marshhay cordgrass, seashore dropseed, pennywort (*Hydrocotyle bonariensis*), and partridge pea (*Chamaecrista fasciculata*).

Clay and migrating dunes are found on the mainland as you move southward along the Texas coast to a more arid climate. Clay dunes form as topographic features downwind of saline flats when blowing clay particles or pellets accumulate. It is possible that they are more extensive here than in any other coastal region of the world (Tunnell and Judd, 2002). Migrating or active dunes, which are common in the dryer environments, are devoid of vegetation and highly susceptible to wind erosion. These unstable dunes can stand as much as 30 feet high and often grade into vegetated dunes (Fulbright, 1990).

3.4.6 Upland Coastal Grasslands

Virtually all of the original coastal prairie community in Texas has been converted to agricultural and development uses. Undeveloped upland grasslands usually consist of a mix of the original prairie species and introduced pasture species as well as various forbs and occasional shrubs such as honey mesquite (*Prosopis glandulosa*), eastern baccharis (*Baccharis halimifolia*) and southern wax-myrtle (*Myrica cerifera*). Hatch et al. (1990) list common species as follows: little bluestem (*Schizachyrium scoparium*), coastal bluestem (*S. scoparium* var. *littoralis*), yellow indiangrass (*Sorgastrum nutans*), eastern gammagrass (*Tripsacum dactyloides*), hairyawn muhly (*Muhlenbergia capillaris*), Texas wintergrass (*Stipa leucotricha*), panicgrasses (*Panicum* spp.), several *Paspalum* species, broomsedge (*Andropogon virginicus*), smutgrass (*Sporobolus indicus*), threeawn grasses (*Aristida* spp.), yankeeweed (*Eupatorium compositifolium*), western ragweed (*Ambrosia cumanensis*), prickly pear (*Opuntia* spp.), several *Aster* species, Texas paintbrush (*Castilleja indivisa*), poppy mallows (*Callirhoe* spp.), phlox (*Phlox* spp.), bluebonnets (*Lupinus* spp.), and evening primrose (*Oenothera* spp.).

3.5 FINFISH AND SHELLFISH RESOURCES

The environmental fluctuations within the Laguna Madre are extreme and the inhabitant biota reflect this lack of stability in the environment (Warshaw, 1975). Large changes in habitat occur on a daily basis with respect to wind, tidal action, salinity regimes, and occasionally freshwater inflow. These ongoing natural processes, coupled with natural events such as freezes, droughts, hurricanes, and anthropogenic pressures (i.e., management practices and coastal projects) all contribute pressure to the Laguna Madre ecosystem. Nevertheless, the biological community present in the Laguna Madre remains diverse and abundant. For example, Breuer (1962) compiled an annotated list of fauna of the LLM which included 104 invertebrate species and 80 fish species. More recently, Tunnell et al. (1996) reports 234 fish species within the Corpus Christi Bay National Estuary Program (CCBNEP) study area which includes the ULM. In addition, Sheridan (1998) reported a diverse community of nekton (fish and decapods) present along six dredged material placement areas (three each in the ULM and LLM). In that evaluation, 79 taxa comprising 20,636 individuals were collected.

Although adding pressure to the ecosystem, these same natural processes and events increase the diversity and abundance of organisms in the Laguna Madre ecosystem. The high energy flow in the Laguna Madre attributed in part to the shallow water depth with respect to a large surface area results in high phytoplankton primary production (Tunnell et al., 1996). The higher salinities and reduced level of nutrients also play major roles in increasing the ecological efficiency. This high ecological efficiency found in the Laguna Madre results in the high abundances of the higher level consumers, like benthic mollusks, and fishes (Tunnell et al., 1996).

A second factor regarding the diversity and abundance of organisms is past and present management strategies. As stated in CCBNEP-06C (1996), "Management strategies are affected by estimated population densities, biology of target organisms, habitat quality, fishing technology, consumer demand, economic value, and special interest group demands". The competing forces of recreational and commercial fishers have led to management activities along the Texas coast including the elimination of gillnets in Texas bays, as well as the designation of red drum (*Sciaenops ocellatus*) and spotted seatrout (*Cynoscion nebulosus*) as game species (CCBNEP-06C, 1996). The opening of inlets to and through the Laguna (i.e., Port Mansfield Channel, the GIWW) has also played a role in the biological productivity in lowering salinity concentrations and providing means for ingress/egress of aquatic organisms.

3.5.1 Recreational and Commercial Species

The principal finfish harvested by sport-boat anglers in the Laguna Madre from 1982 to 1992 were spotted seatrout, red drum, southern flounder (*Paralichthys lethostigma*), black drum (*Pogonias cromis*), and sheepshead (*Archosargus probatocephalus*) (Warren et al., 1994). In comparison to all Texas bay systems, the LLM supported the largest percentage of red drum caught by private-boat fishermen for the period from 1982 to 1992 (Warren et al., 1994). The LLM also maintained the highest percentage of coastwide bay and pass party-boat fishing pressure (26%) and landings (24%) from 1988 to 1998, while the ULM was responsible for 17 percent of coastwide fishing pressure and 17 percent of landings for the same time period (Campbell, 2002). Recreational boat landings since 1974 for all finfish have shown a decline, which may be due to shifts in effort and regulations (Warren et al., 1994).

The most important commercial finfish species currently reported from the Laguna Madre are black drum, flounder (*Paralichthyes* spp.), sheepshead, and striped mullet (*Mugil cephalus*) (Tables 3-1 and 3-2) (Auil-Marshalleck et al., 2001). In 1996, commercial black drum landings increased to record highs in the ULM (Fuls and McEachron, 1997; Auil-Marshalleck et al., 2001). From 1972 to 1999 in the ULM, black drum landings increased; whereas flounder, sheepshead, and striped mullet decreased. For the same period, in the LLM, black drum, flounder, and striped mullet landings have increased and sheepshead have decreased (Auil-Marshalleck et al., 2001). However, during the last 5 years (1995–1999) 59 percent of the finfish in Texas bays were landed in the Laguna Madre (ULM = 41%; LLM = 18%) (Auil-Marshalleck et al., 2001).

The main shellfish species in the Laguna Madre include brown shrimp (*Farfantepenaeus aztecus*), pink shrimp (*Farfantepenaeus duorarum*), white shrimp (*Litopenaeus setiferus*), blue crab (*Callinectes sapidus*), and eastern oyster (Tables 3-1 and 3-2). Within the Laguna Madre, as with the Texas coast in general, brown shrimp are far more common than the other two shrimp species. In general, the Laguna Madre does not support a significant commercial shellfish industry. TPWD reports that during 1995 to 1999, only 1 percent or less of the total Texas coastal landings for brown, white, and pink shrimp, or blue crab occurred in the Laguna Madre (Auil-Marshalleck et al., 2001). In addition, there have been no eastern oyster landings reported by TPWD from the Laguna Madre during that same 5-year period (Auil-Marshalleck et al., 2001). Since 1972, the landings for shellfish in the Laguna Madre have been varied but typically quite limited.

3.5.2 Aquatic Communities

In addition to the finfish discussed above as having valuable recreational and commercial value to humans, there are many additional aquatic communities present in the Laguna Madre that serve to support the ecological diversity and abundance. The sheepshead minnow (*Cyprinodon variegatus*),

TABLE 3-1

TEXAS COMMERCIAL LANDINGS FOR UPPER LAGUNA MADRE
ANNUAL SUMMARIES, 1990-1999

Species	1990 lbs. (x 1,000)	1990 $ (x 1,000)	1991 lbs. (x 1,000)	1991 $ (x 1,000)	1992 lbs. (x 1,000)	1992 $ (x 1,000)	1993 lbs. (x 1,000)	1993 $ (x 1,000)	1994 lbs. (x 1,000)	1994 $ (x 1,000)	1995 lbs. (x 1,000)	1995 $ (x 1,000)	1996 lbs. (x 1,000)	1996 $ (x 1,000)	1997 lbs. (x 1,000)	1997 $ (x 1,000)	1998 lbs. (x 1,000)	1998 $ (x 1,000)	1999 lbs. (x 1,000)	1999 $ (x 1,000)
Fish																				
Black Drum	218.05	241.72	181.91	194.14	197.55	175.20	230.23	170.14	587.84	478.65	1,326.66	1,133.15	2,016.54	1,921.23	1,226.09	1,014.96	1,363.38	1,442.45	1,463.05	1,501.83
Flounder	0.92	3.01	4.34	8.22	2.33	4.43	0.91	1.64	0.53	1.01	1.23	2.56	0.36	0.89	1.65	2.90	0.54	0.76	1.37	1.75
Mullet	0	0	0	0	0.04	0.05	0.09	0.19	1.24	2.58	0.91	2.15	0.72	1.72	0.25	0.56	0.46	1.20	0.29	0.20
Sheepshead	0.49	0.26	0.25	0.12	0.01	0.06	0	0	0.35	0.19	0.59	0.34	4.85	3.25	0.13	0.11	1.28	0.76	0.46	0.27
TOTAL FISH	**219.46**	**244.99**	**186.50**	**202.48**	**199.93**	**179.74**	**231.23**	**171.97**	**589.96**	**482.43**	**1,329.39**	**1,138.20**	**2,022.47**	**1,927.09**	**1,228.12**	**1,018.53**	**1,365.65**	**1,445.17**	**1,465.17**	**1,504.05**
Shellfish																				
Crabs, Blue	25.77	13.27	3.65	2.53	472.64	236.24	63.16	41.33	69.37	35.97	7.43	5.93	23.39	16.50	0.11	0.16	3.94	2.29	3.92	2.17
Oyster Meats	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shrimp (Heads On):																				
Brown and Pink	7.05	11.84	36.25	42.99	175.18	251.69	74.22	91.82	258.29	428.62	11.39	22.72	39.64	35.46	8.89	14.71	54.23	55.77	0.35	0.46
White	19.99	27.50	0	0	0.30	0.89	7.24	12.43	11.59	29.89	0.08	0.14	1.22	1.89	0.25	0.95	1.81	4.42	0	0
TOTAL SHELLFISH	**52.81**	**52.61**	**39.90**	**45.52**	**648.12**	**488.82**	**144.62**	**145.58**	**339.25**	**494.48**	**18.90**	**28.79**	**64.25**	**53.85**	**9.25**	**15.82**	**59.98**	**62.49**	**4.27**	**2.63**
GRAND TOTAL	**272.27**	**297.60**	**226.40**	**248.00**	**848.05**	**668.56**	**375.85**	**317.55**	**929.21**	**976.91**	**1,348.29**	**1,166.99**	**2,086.72**	**1,980.94**	**1,237.37**	**1,034.35**	**1,425.63**	**1,507.65**	**1,469.43**	**1,506.68**

Source: Auil-Marshalleck et al., 2001

TABLE 3-2

TEXAS COMMERCIAL LANDINGS FOR LOWER LAGUNA MADRE ANNUAL SUMMARIES, 1990-1999

Species	1990		1991		1992		1993		1994		1995		1996		1997		1998		1999	
	lbs. (x 1,000)	$ (x 1,000)	lbs. (x 1,000)	$ (x 1,000)	lbs. (x 1,000)	$ (x 1,000)	lbs. (x 1,000)	$ (x 1,000)	lbs. (x 1,000)	$ (x 1,000)	lbs. (x 1,000)	$ (x 1,000)	lbs. (x 1,000)	$ (x 1,000)	lbs. (x 1,000)	$ (x 1,000)	lbs. (x 1,000)	$ (x 1,000)	lbs. (x 1,000)	$ (x 1,000)
Fish																				
Black Drum	218.05	103.33	332.63	163.57	281.72	158.83	236.06	165.57	594.66	419.46	511.89	380.06	952.91	758.35	619.00	412.39	430.99	429.77	528.24	438.66
Flounder	0.92	32.24	79.42	68.97	56.74	58.05	27.78	42.49	20.05	37.01	30.89	40.20	20.49	39.12	12.22	26.54	41.24	89.70	61.50	138.14
Mullet	0	0	0	0	1.34	1.31	4.06	4.06	6.23	8.36	7.96	11.29	5.34	9.95	8.31	11.93	8.59	13.87	13.86	20.08
Sheepshead	3.49	1.25	7.77	1.41	1.15	0.21	0.48	0.21	2.47	1.40	1.45	0.58	2.05	1.00	1.79	0.98	6.43	2.53	2.71	1.62
TOTAL FISH	**222.46**	**136.82**	**419.82**	**233.95**	**340.95**	**218.40**	**268.38**	**212.33**	**623.41**	**466.23**	**552.19**	**432.13**	**980.79**	**808.42**	**641.32**	**451.84**	**487.24**	**535.86**	**606.31**	**598.50**
Shellfish																				
Crabs, Blue	0.98	0.69	13.03	4.64	53.51	22.96	0.33	0.21	2.72	1.94	12.48	12.04	6.56	6.59	5.79	5.55	246.70	167.08	70.67	50.77
Oyster Meats	5.20	16.19	5.06	12.62	3.62	8.88	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shrimp (Heads On):																				
Brown and Pink	0.34	0.59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL SHELLFISH	**6.52**	**17.47**	**18.09**	**17.26**	**57.13**	**31.84**	**0.33**	**0.21**	**2.72**	**1.94**	**12.48**	**12.04**	**6.56**	**6.59**	**5.79**	**5.55**	**246.70**	**167.08**	**70.67**	**50.77**
GRAND TOTAL	**228.98**	**154.29**	**437.91**	**251.21**	**398.08**	**250.24**	**268.71**	**212.54**	**626.13**	**468.17**	**564.67**	**444.17**	**987.35**	**815.01**	**647.11**	**457.39**	**733.95**	**702.94**	**676.98**	**649.27**

Source: Auil-Marshalleck et al., 2001.

which feeds on blue-green algae is one of relatively few species occurring on the previously described mud/algal flats when flooded (Warshaw, 1975). Warshaw (1975) adds that other species found mainly in shallow areas, though not confined to the tidal flats, include the longnose killifish (*Fundulus similis*), Gulf killifish (*F. grandis*), and tidewater silverside (*Menidia peninsulae*). Inhabitants of SAV meadows include the pinfish (*Lagodon rhomboides*), silver perch (*Bairdiella chrysura*), sheepshead, and pigfish (*Orthopristis chrysoptera*) (Warshaw, 1975). Species often found in deeper water, including the GIWW, include the Atlantic croaker (*Micropogonias undulatus*), Gulf menhaden (*Brevoortia patronus*), and hardhead catfish (*Arius felis*), while a number of fish occur in abundance in both SAV meadows and deeper areas, including such species as the bay anchovy (*Anchoa mitchilli*), spot (*Leiostomus xanthurus*), and striped mullet (Warshaw, 1975).

Important to the entire food chain are the microscopic plankton and SAV, primarily the latter, which utilize nutrients and provide an abundant food source. The plankton community consists of small plants (phytoplankton) and animals (zooplankton) that are suspended in the water column. Diverse and abundant plankton communities exist throughout the Laguna Madre.

The benthic macroinvertebrates of the Laguna Madre form a highly diverse group of organisms with a wide variety of functions in the aquatic community. In addition to serving as a major food source for vertebrate predators such as fish, macroinvertebrates have important roles as herbivores, detritivores, and carnivores. Calnan et al. (1986) reported that benthic macroinvertebrates found in the sediments of the LLM were primarily polychaetes, bivalves, gastropods, and crustaceans. Calnan et al. (1986) reported that the distributions of the macroinvertebrates were related to bathymetry and sediment type. More recent studies (EH&A, 1998b, and Sheridan, 1998) have been conducted to evaluate changes in benthic communities in response to open-water placement of dredged material.

EH&A (1998b) evaluated the benthic macroinfaunal community composition within the Laguna Madre in conjunction with the evaluation of environmental impacts of the historic practice of open-water placement of dredged material. The purpose of the study was to characterize the benthic community at two different times of the year in and near PAs in the ULM and LLM and at reference sites across the GIWW from the selected PAs (EH&A, 1998b). A total of 92,649 individuals representing 396 taxa were identified from 178 discrete samples in the spring sampling, and 26,015 individuals representing 308 taxa were identified from 177 discrete samples during the fall sampling event (EH&A, 1998b). During both times of the year, polychaetes composed the majority of individuals and the greatest number of taxa (EH&A, 1998b). The final conclusions of the report were that composition of benthic assemblages reflected geographic rather than placement-related trends with all patterns indicating that placement practices have had little influence on the composition of the benthic macroinfaunal communities in the Laguna Madre (EH&A, 1998b).

Sheridan (1998) examined the temporal and spatial effects of open-water placement of dredged material on habitat utilization. The objective of the study was to document how long alterations in habitat were detectable and to determine the spatial extent of such alterations. Three PAs in both the ULM and LLM were examined and at each PA, three habitats were examined: Maximum Impact Habitat (subtital dredged material deposits at the center of placement areas that were devoid of SAV at the beginning of the study), Minimum Impact Habitat (seagrass areas roughly 16.5 feet from the outward edge of the dredged material), and Natural Seagrass Habitat (seagrass beds at least 3,300 feet from the PA). Samples were collected every fall and spring from September 1995 through April 1998 at five replicate sites within each habitat. A diverse community of benthic organisms was revealed with over 220 taxa and 78,145 individuals collected (Sheridan, 1998). Of these, 59 percent were annelids, 34 percent were non-decapod crustaceans, 6 percent were mollusks, and 1 percent were comprised of miscellaneous taxa (Sheridan, 1998). The study concluded that impacts to the benthic community in the Maximum Impact Habitat would continue for at least 1.5 years at the Maximum Impact Habitat for some parameters and beyond 3 years for others. Most of the originally non-vegetated dredged material, which was not too deep or too shallow to revegetate, had revegetated after 3 years. Sheridan (1998) states that complete revegetation may take 5 years. Since dredging and placement occur at periods less than this, the benthos at the Maximum Impact Habitat may not recover.

3.5.3 Essential Fish Habitat

Congress enacted amendments to the Magnuson-Stevens Fishery Conservation and Management Act (PL 94-265) in 1996 that established procedures for identifying Essential Fish Habitat (EFH) and required interagency coordination to further the conservation of Federally managed fisheries. Rules published by the NMFS (50 CFR Sections 600.805 – 600.930) specify that any Federal agency that authorizes, funds or undertakes, or proposes to authorize, fund, or undertake an activity which could adversely affect EFH is subject to the consultation provisions of the above mentioned act and identifies consultation requirements. This section was prepared to meet these requirements.

The Gulf of Mexico Fishery Management Council (GMFMC) has identified the project area as EFH for adult and juvenile brown, white, and pink shrimp; red drum; adult Spanish mackerel (*Scomberomorus maculatus*); and juvenile gray snapper (*Lutjanus griseus*).

EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." When referring to estuaries, it is further defined as "all waters and substrates (mud, sand, shell, rock and associated biological communities) within these estuarine boundaries, including the sub-tidal vegetation (seagrasses and algae) and adjacent tidal vegetation (marshes and mangroves)" (GMFMC, 1998).

3.5.3.1 Description of EFH Managed Species

The following describes the preferred habitat, life history stages, and relative abundance of each EFH managed species based on information provided by GMFMC (1998).

Brown Shrimp: Brown shrimp eggs are demersal and occur offshore. The larvae occur offshore and begin to migrate to estuaries as postlarvae. Postlarvae migrate through passes on flood tides at night mainly from February to April with a minor peak in the fall. In estuaries, brown shrimp postlarvae and juveniles are associated with shallow vegetated habitats but also are found over silty sand and non-vegetated mud bottoms. Postlarvae and juveniles have been collected in salinity ranging from zero to 70 ppt. The density of late postlarvae and juveniles is highest in marsh edge habitat and submerged vegetation, followed by tidal creeks, inner marsh, shallow open water and oyster reefs; in unvegetated areas, muddy substrates seem to be preferred. Juveniles and sub-adults of brown shrimp occur from secondary estuarine channels out to the continental shelf but prefer shallow estuarine areas, particularly the soft, muddy areas associated with plant-water interfaces. Sub-adults migrate from estuaries at night on ebb tide of the new and full moons. Abundance offshore correlates positively with turbidity and negatively with hypoxia (low levels of oxygen in the water). Adult brown shrimp occur in neritic Gulf waters (i.e., marine waters extending from mean low tide to the edge of the continental shelf) and are associated with silt, muddy sand, and sandy substrates (GMFMC, 1998). Brown shrimp are common to highly abundant throughout the Laguna Madre year-round. Refer to Table 3-3 for adult and juvenile presence in the Laguna Madre.

Marine habitat is critically important to the reproduction and survival of shrimp. Adult brown shrimp occur throughout the Gulf's marine habitat to depths of about 360 feet.

Larval shrimp feed on phytoplankton and zooplankton. Postlarvae feed on phytoplankton, epiphytes, and detritus. Juveniles and adults prey on amphipods, polychaetes, and chironomid larvae in addition to algae and detritus (Pattillo et al., 1997). The habitat of these prey is essentially the same as that required by shrimp, estuarine and marine.

White Shrimp: White shrimp are offshore and estuarine dwellers and are pelagic or demersal, depending on life stage. Their eggs are demersal and larval stages planktonic, both occurring in nearshore marine waters. Postlarvae migrate through passes mainly from May to November with peaks in June and September. Migration is in the upper 7 feet of the water column at night and at mid-depths during the day. Postlarval white shrimp become benthic once they reach the estuary, where they seek shallow water with muddy-sand bottoms high in organic detritus or rich marsh where they develop into juveniles. Postlarvae and juveniles inhabit mostly mud or peat bottoms with large quantities of decaying organic matter or vegetative cover. Densities are usually highest in marsh edges and SAV, followed by marsh ponds and channels, inner marsh, and oyster reefs. White shrimp juveniles prefer salinities of less than 10 ppt and can be found in tidal rivers and tributaries. As juveniles mature, they move to coastal areas where they mature and spawn. Adult white shrimp move from estuaries to coastal areas, where they are demersal and inhabit soft mud or silt bottoms (GMFMC, 1998). White shrimp are common to abundant throughout the Laguna Madre year-round. Refer to Table 3-3 for adult and juvenile presence in the Laguna Madre.

Marine habitat is critically important to the reproduction and survival of shrimp. Adult white shrimp occur throughout the Gulf's marine habitat to depths of about 130 feet.

Larval shrimp feed on phytoplankton and zooplankton. Postlarvae feed on phytoplankton, epiphytes, and detritus. Juveniles and adults prey on amphipods, polychaetes, and chironomid larvae but also on algae and detritus (Pattillo et al., 1997). The habitat of these prey is essentially the same as that required by shrimp, both estuarine and marine.

TABLE 3-3

ESSENTIAL FISH HABITAT - ADULT AND JUVENILE PRESENCE
IN THE LAGUNA MADRE PROJECT AREA

Species	Corpus Christi Bay *		Baffin Bay and Upper Laguna Madre		Lower Laguna Madre	
	Adults	Juvenile	Adults	Juvenile	Adults	Juvenile
Brown Shrimp (*Farfantepenaeus aztecus*)	--	*common* year-round	*common* January - July	*common* January - July *abundant* August - December	*common* April - October	*abundant* August - March *highly abundant* April - July
White Shrimp (*Litopenaeus setiferus*)	*abundant* August - March *common* April - June	*abundant* July, August - October *common* November - June	*common* January - July	*common* January - July *abundant* August - December	--	*common* year-round
Pink Shrimp (*Farfantepenaeus duorarum*)	--	*common* August - June	*common* January - July *abundant* August - December	*common* August - December *abundant* January - July	--	*common* January - July
Red Drum (*Sciaenops ocellatus*)	*common* year-round	*common* year-round	*common* year-round	*common* year-round	*common* year-round	*common* year-round
Gray Snapper (*Lutjanus griseus*)	--	--	--	*common* April - October	--	--
Spanish Mackerel (*Scomberomorus maculatus*)	*common* April - October	--	*common* April - October	--	*common* April - October	--

* Corpus Christi Bay includes the upper most portion of the Upper Laguna Madre and is therefore included in this table.

Pink Shrimp: After spawning offshore, postlarval pink shrimp recruitment into the estuaries occurs in the spring and fall through passes. Juveniles can be found in SAV meadows where they burrow into the substrate; however, postlarvae, juvenile, and adults may prefer a mixture of course sand/shell/mud. Densities of pink shrimp are lowest or absent in marshes, low in mangroves, and greatest near or in SAV. Adults occur offshore in depths of 30 to 145 feet and prefer substrates of coarse sand and shell (GMFMC, 1998). Pink shrimp are common to abundant throughout the Laguna Madre year-round. Refer to Table 3-3 for adult and juvenile presence in the Laguna Madre.

Marine habitat is critically important to the reproduction and survival of shrimp. Adult pink shrimp occur throughout the Gulf's marine habitat to depths of about 215 feet.

Larval shrimp feed on phytoplankton and zooplankton. Postlarvae feed on phytoplankton, epiphytes, and detritus. Juveniles and adults prey on amphipods, polychaetes, and chironomid larvae but also on algae and detritus (Pattillo et al., 1997). The habitat of these prey is essentially the same as that required by shrimp, estuarine and marine.

Red Drum: Red drum occupy a variety of habitats, ranging from depths of 130 feet offshore to very shallow estuarine waters. Spawning occurs in the Gulf near the mouths of bays and inlets in the fall and winter months. Eggs hatch mainly in the Gulf, and larvae are transported into the estuary where they mature before moving back to the Gulf to spawn. Adult red drum use estuaries, but tend to spend most of their time offshore as they age. They are found over a variety of substrates, including sand, mud, and oyster reefs, and can tolerate a wide range of salinities (GMFMC, 1998). Within the Laguna Madre, adult and juvenile red drum are common year-round. Refer to Table 3-3 for adult and juvenile presence in the Laguna Madre

Estuaries are especially important to the larval, juvenile, and sub-adult red drum. Juvenile red drum are most abundant around marshes, preferring quiet, shallow, protected waters with muddy or grassy bottoms (Simmons and Breuer, 1962). Sub-adult and adult red drum prefer shallow bay bottoms and oyster reef substrates (Miles, 1950).

Estuaries are also important to the prey species of red drum. This is essential to larvae, juvenile, and early adult red drum since they spend all of their time in the estuary. Larval red drum feed mainly on shrimp, mysids, and amphipods, while juveniles feed on more fish and crabs (Peters and McMichael, 1988). Adult red drum feed mainly on shrimp, blue crab, striped mullet, and pinfish. Protection of estuaries is important to maintain the essential habitat for red drum and because so many prey species of red drum are estuarine dependent (GMFMC, 1998).

Gray Snapper: Gray snapper are demersal mid-water dwellers inhabiting marine, estuarine, and riverine habitats. They occur to depths of about 600 feet offshore. Gray snapper prefer SAV beds, mangroves, and coral reefs over rocky, sandy and muddy bottoms. Spawning occurs offshore from June to August around artificial structures and shoals. Eggs are pelagic and larvae are planktonic, both occurring in offshore shelf waters and near coral reefs. Postlarvae migrate into the estuaries and are most abundant over shoalgrass and manateegrass beds. Juveniles seem to prefer turtlegrass beds, SAV meadows, marl bottoms, and mangrove roots within estuaries, bayous, channels, SAV beds, marshes, mangrove swamps, ponds and freshwater creeks (GMFMC, 1998). Juvenile gray snapper are common in Baffin Bay and the ULM from April to October (Table 3-3).

Gray snapper feed on estuarine-dependent organisms such as shrimp, small fish, and crabs during their juvenile stages. This species is classified as an opportunistic carnivore at all life stages (Pattillo et al., 1997). In the estuary, juvenile gray snapper feed on shrimp, larval fish, amphipods, and copepods. At offshore reefs, adults feed primarily on fish and secondarily on crustaceans; larger gray snapper will eat proportionately more fish (GMFMC, 1998).

Spanish Mackerel: Spanish mackerel are pelagic, occurring at depths to 250 feet throughout the coastal zone of the Gulf of Mexico. Adults are usually found along coastal areas, extending out to the edge of the continental shelf; however, they also display seasonal migrations and will inhabit high salinity estuarine areas at times. The occurrence of adults in Gulf estuaries is infrequent and rare. Spawning occurs in offshore waters during May through October. Nursery areas are in estuaries and coastal waters year-round. Larvae are most often found offshore from depths of 30 to 275 feet. Juveniles are found offshore, in the surf area, and sometimes in estuarine habitats. Juveniles prefer marine salinities and are not considered estuarine-dependent. The substrate preference of juveniles is clean sand; the preferences of other life stages are unknown (GMFMC, 1998). Adult Spanish mackerel are found in Corpus Christi Bay and the ULM from April to October (Table 3-3).

Estuaries are important habitats for most of the major prey species of Spanish mackerel. They feed throughout the water column on a variety of fishes, especially herrings. Squid, shrimp, and other crustaceans are also eaten. Most of their prey species are estuarine-dependent, spending all or a portion of their lifecycle in estuarine. Because of this, Spanish mackerel are also dependent on the estuaries to some degree and, therefore, can be expected to be detrimentally affected if the productive capabilities of estuaries are seriously degraded (GMFMC, 1998).

3.6 WILDLIFE RESOURCES

The study area lies within Tamaulipan biotic province as described by Blair (1950). The area is semiarid and hot, with a marked deficiency of moisture for plant growth. The vertebrate fauna of this province includes considerable elements of neotropical as well as plains species. Wildlife habitats found within the project area include upland prairies, salt marsh, and tidally influenced lowlands. The coastal wetlands of the Laguna Madre are represented by salt marshes (previously defined in Section 3.4.2) on the bay side of the barrier islands, a large, open saline lagoon, and a narrow belt of mainland salt marshes backed by relatively unspoiled coastal prairie. The Laguna Madre supports several Audubon sanctuaries, documented migratory/waterbird nesting sites, a large national park, and coastal preserves in and near the study area (Figure 3-2a–c).

Two dedicated natural areas, the PINS and the LANWR, lie partially within the study area. PINS encompasses over 130,000 acres of habitat on Padre Island. This seashore, managed by the NPS, consists primarily of coastal prairies and grasslands, with ephemeral marshes, ponds, and tidal flats on

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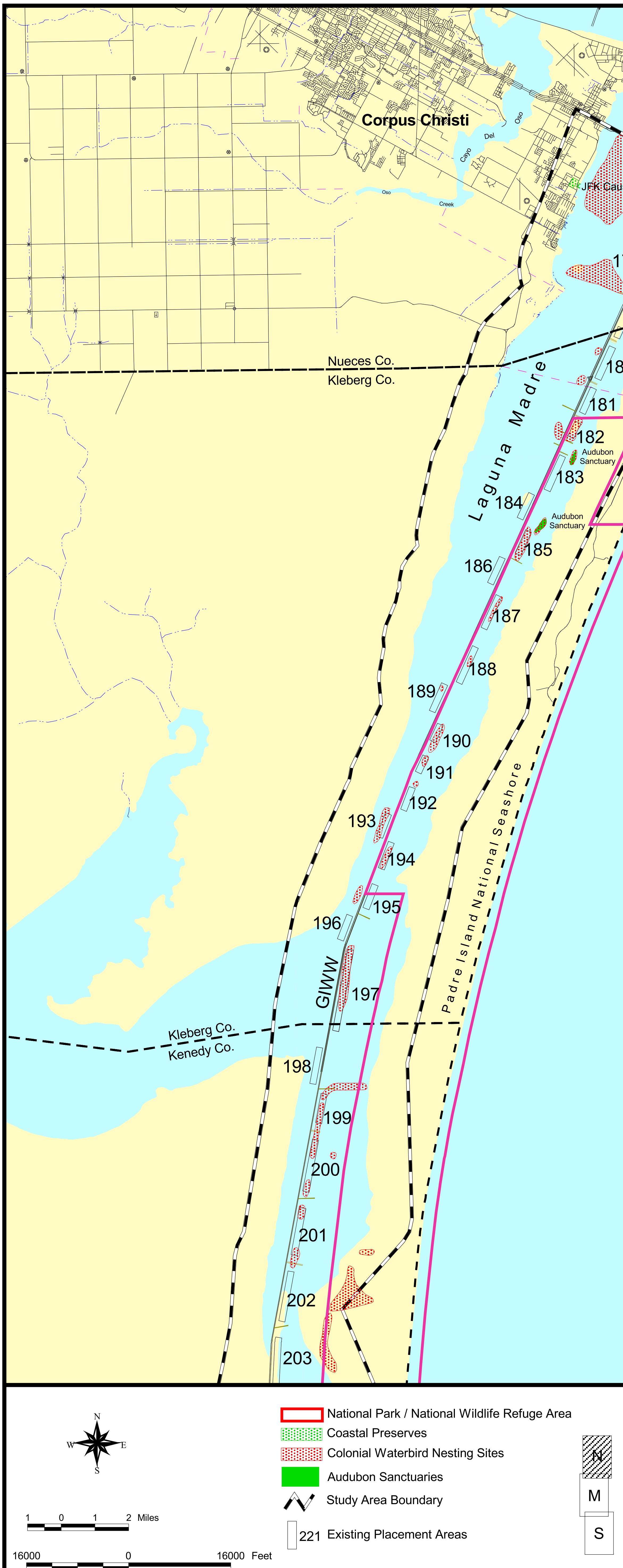

LAGUNA MADRE EIS

Figure 3-2a
Special Wildlife Habitat Areas
Laguna Madre

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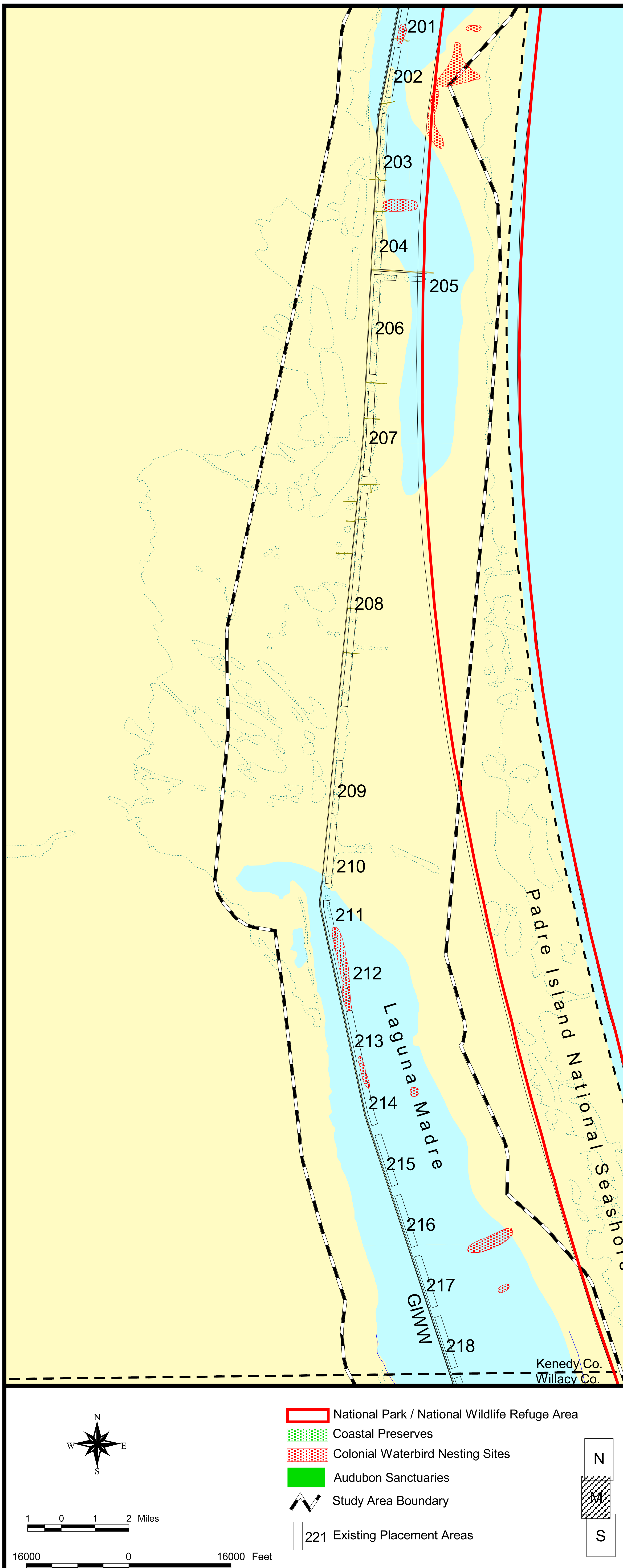

LAGUNA MADRE EIS

Figure 3-2b
Special Wildlife Habitat Areas
Laguna Madre

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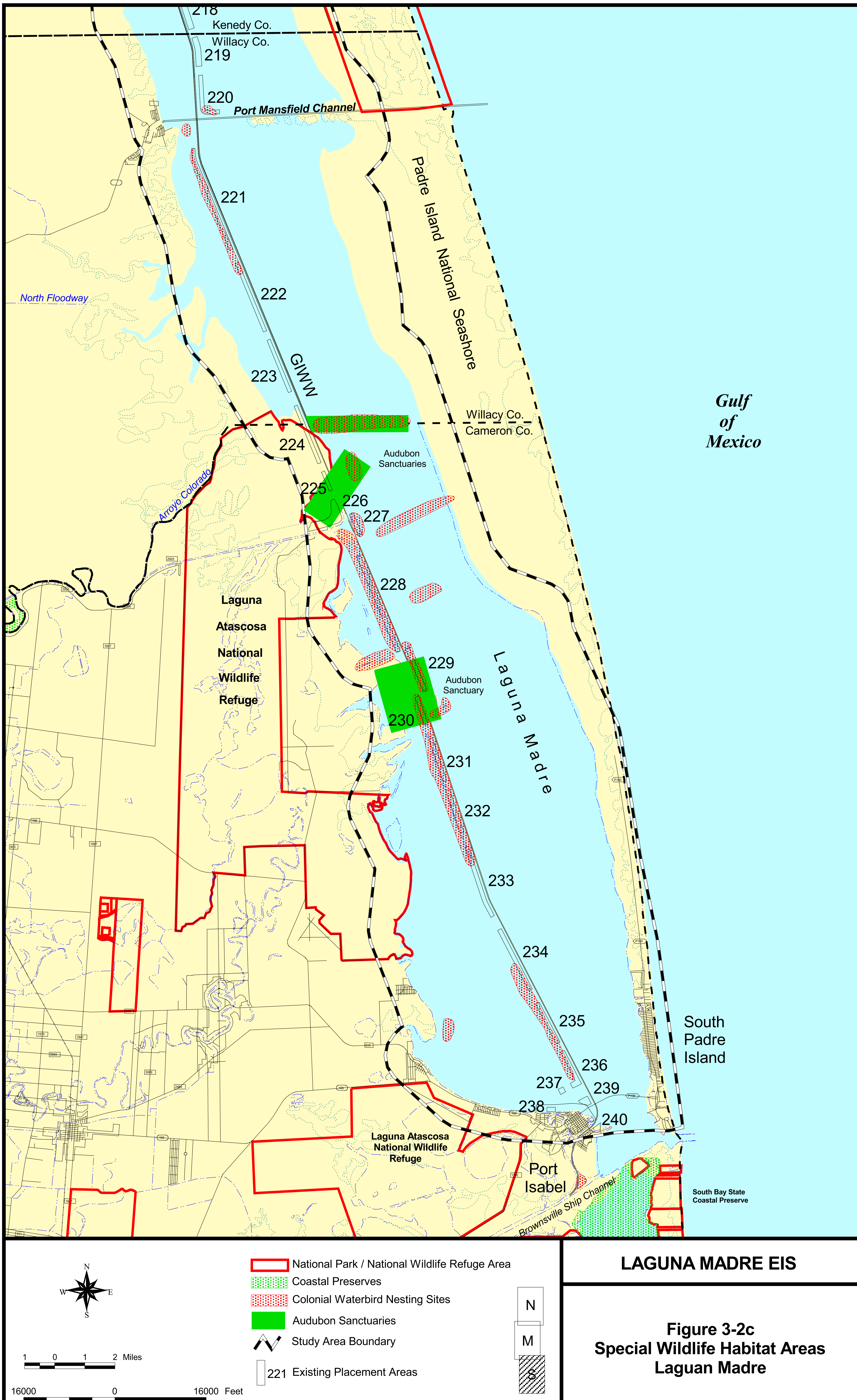

LAGUNA MADRE EIS

Figure 3-2c
Special Wildlife Habitat Areas
Laguan Madre

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the western side of the barrier island bordering the Laguna Madre. The LANWR is owned and managed by the FWS. It has very little topographic variation and consists primarily of meandering resacas (old Rio Grande oxbows), lomas, and coastal salt flats, in addition to Lake Atascosa, for which it is named. The FWS also manages areas of cropland and grassland within LANWR, completing a diverse array of habitats for birds and mammals. The Audubon sanctuaries are associated with LANWR in the LLM and North and South Bird islands in the ULM.

The Tamaulipan biotic province supports a diverse fauna composed of a mixture of species that are common in surrounding regions. The fauna includes a substantial number of neotropical species from the south, large number of plains species from the north and northwest, a few woodland species from the northeast, and some desert species from the west and southwest (Blair, 1950).

At least 19 species of lizards (Blair, 1950) and 38 species of snakes (Werler and Dixon, 2000) occur or have occurred in the Tamaulipan biotic province. Amphibians of potential occurrence in the study area include such amphibians as Blanchard's cricket frog (*Acris crepitans blanchardi*), Gulf coast toad (*Bufo valliceps*), and southern leopard frog (*Rana sphenocephala*). Terrestrial reptiles of potential occurrence in the study area include the Texas yellow-headed racerunner (*Cnemidophorus sexlineatus stephensae*), northern keeled earless lizard (*Holbrookia propinqua propinqua*), Texas spotted whiptail (*Cnemidophorus gularis gularis*), western coachwhip (*Masticophis flagellum testaceus*), Gulf coast ribbon snake (*Thamnophis proximus orarius*), and western diamondback rattlesnake (*Crotalus atrox*). Additionally, the Texas diamondback terrapin, the only turtle to be entirely restricted to estuarine habitats, reaches the southernmost extent of its range in the northern reaches of the ULM (Bartlettt and Bartlett, 1999). Five species of sea turtles are also known to occur within the Gulf of Mexico and associated bays. These sea turtles include the loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), Atlantic hawksbill sea turtle (*Eretmochelys imbricata imbricata*), and Kemp's ridley sea turtle (*Lepidochelys kempii*).

The immediate study area and vicinity support an abundant and diverse avifauna. Tidal flats and beaches create excellent habitat for numerous species of gulls, terns, herons, shorebirds, and wading birds. Numerous colonial waterbird rookeries are located on emergent dredged material islands throughout the study area. Some common species which occur within the project area include the laughing gull (*Larus atricilla*), ring-billed gull (*Larus delawarensis*), royal tern (*Sterna maxima*), Forster's tern (*Sterna forsteri*), great blue heron (*Ardea herodias*), little blue heron (*Egretta caerulea*), sanderling (*Calidris alba*), willet (*Catoptrophorus semipalmatus*), least sandpiper (*Calidris minutilla*), roseate spoonbill (*Ajaia ajaja*), and white ibis (*Eudocimus albus*). The coastal areas of the Rio Grande Valley support high populations of a very diverse avifauna during migration and in the winter, including many tropical species reaching the northern limit of their ranges.

The Laguna Madre is located on the southern end of the Central Flyway and is one of the most significant waterfowl wintering regions in North America, with 3 to 5 million waterfowl wintering annually in Texas (TCMP, 1996). The shallow saline Laguna Madre provides important feeding grounds for winter waterfowl populations that feed on seagrasses and mollusks and crustaceans associated with the underwater vegetation. Waterfowl species use open-water habitats of the Laguna Madre, as well as nearby freshwater wetlands in the adjacent mainland and barrier island communities. Waterfowl species wintering in the Laguna Madre system include the redhead (*Aythya americana*), green-winged teal (*Anas crecca*), northern pintail (*Anas acuta*), canvasback (*Aythya valisineria*), American wigeon (*Anas americana*), gadwall (*Anas strepera*), lesser scaup (*Aythya affinis*), northern shoveler (*Anas clypeata*), ruddy duck (*Oxyura jamaicensis*), blue-winged teal (*Anas discors*), and mottled duck (*Anas fulvigula*) (TPWD, 2001; Tunnell and Judd, 2002). Approximately 80 percent of the North American population of redheads winters in the Laguna Madre. Over 500,000 redheads were counted along the Texas Gulf Coast during a recent TPWD mid-winter waterfowl survey; however, numbers may fluctuate annually (TPWD, 2002). Shoalgrass rhizomes are the primary winter food source for redheads and the distribution of redheads in the Laguna Madre is closely tied to the distribution of shoalgrass meadows (Tunnell and Judd, 2002). The Laguna Madre also provides year-round habitat for mottled ducks. Other bird species which are associated with prairies and marshes include many species of raptors and songbirds.

At least 61 mammalian species occur or have occurred within recent times in the Tamaulipan Biotic Province (Blair, 1950). Terrestrial mammals likely to occur in the study area include the black-tailed jackrabbit (*Lepus californicus*), Gulf Coast kangaroo rat (*Dipodomys compactus*), marsh rice rat (*Oryzomys palustris*), hispid cotton rat (*Sigmodon hispidus*), common raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and coyote (*Canis latrans*). Marine mammals are also likely to occur within the Laguna Madre and associated waters. The bottle-nosed dolphin (*Tursiops truncatus*) is likely to be the most frequently encountered marine mammal.

3.7 THREATENED AND ENDANGERED SPECIES

The Endangered Species Act (ESA) [16 U.S.C. 1531 et. Seq.] of 1973 as amended, was enacted to provide a program for the preservation of endangered and threatened species and to provide protection for the ecosystems upon which these species depend for their survival. All Federal agencies are required to implement protection programs for these designated species and to use their authorities to further the purposes of the act. The FWS and NMFS are the primary agencies responsible for implementing the ESA. The FWS is responsible for birds and terrestrial and freshwater species, while the NMFS is responsible for non-bird marine species.

An endangered species is one that is in danger of extinction throughout all or a significant portion of its range. A threatened species is one likely to become endangered within the foreseeable future throughout all or a significant portion of its range. State-listed threatened and endangered species, while addressed in this FEIS, are not protected under the ESA nor are Species of Concern (SOC), which are species for which there is some information showing evidence of vulnerability, but not enough to support a Federal listing. Only those species listed as endangered or threatened by FWS or NMFS are afforded complete Federal protection. It should be noted that inclusion on the following lists does not imply that a species is known to occur in the study area, but only acknowledges the potential for occurrence.

3.7.1 Plants

Table 3-4 presents plant species that may occur in the project area which are considered endangered by the FWS and TPWD. These plants have a geographic range which includes Nueces, Kleberg, Kenedy, Willacy and/or Cameron counties. Five plant species are listed by both the FWS and TPWD as endangered which may potentially occur within the project area counties. These plants include south Texas ambrosia (*Ambrosia cheiranthifolia*), slender rush-pea (*Hoffmannseggia tenella*), Texas ayenia (*Ayenia limitaris*), star cactus (*Astrophytum asterias*), and black lace cactus (*Echinocereus reichenbachii* var. *albertii*). The following paragraphs provide a brief discussion concerning each of the plants listed in Table 3-4.

South Texas ambrosia is an inhabitant of open clay prairies (Correll and Johnston, 1970). Much of its original habitat has been converted to agriculture. It is known in the U.S. from Nueces, Kleberg, and Jim Wells counties and has also been recorded from Tamaulipas, Mexico. Its occurrence in the study area is unlikely. The slender rush-pea is known from only Kleberg and Nueces counties. It is found in barren openings or where native grasses persist in clay soils (FWS, 1995). Introduction of non-native grasses and conversion of prairies to agriculture are thought to be responsible for its decline. It is unlikely to occur in the sandy soils of the project area. Texas ayenia occurs along the alluvial plains of the Rio Grande in Texas ebony-anacua woodlands (FWS, 1995). Its current range now only includes Hidalgo County and Tamaulipas, Mexico (FWS, 1995). This plant is not likely to occur in the project area.

Two endangered cactus are known to have a geographic range which includes the project area counties. In Texas, the star cactus once occurred in Cameron, Starr and Hidalgo counties, but is presently only found in Starr County (FWS, 1995). Habitat includes sparsely vegetated areas at low elevations in the Rio Grande plain in gravelly, saline clays or loamy soils (FWS, 1995). The black lace cactus has a current range in the south Texas plains which includes Jim Wells, Kleberg, and Refugio counties (Poole and Riskind, 1987). This cactus occurs in brushy, grassy areas where the Gulf Coastal Plain meets the inland mesquite/huisache/blackbrush savannah (Poole and Riskind, 1987). These cacti are rare and occurrence within the project area is unlikely.

Ten plant species identified as SOC by the FWS have records in one or more of the study area counties. These species include: lila de los llanos (*Echeandia chandleri*); Texas windmillgrass (*Chloris texensis*); Thieret's skullcap (*Scutellaria thieretii*); Roughseed sea-purslane (*Sesuvium trianthemoides*); Welder machaeranthera (*Psilactis heterocarpa*); Bailey's ballmoss (*Tillandsia baileyi*); marshelder (slender) dodder (*Cuscuata attenuata*); Runyon's huaco (*Manfreda longiflora*); Runyon's water-willow (*Justicia runyonii*); and short-fruited spikerush (*Eleocharis brachycarpa*).

Lila de los llanos occurs on level to gently undulating sites along and inland from the Gulf Coast of Texas. It prefers full sunlight and grows among prairies and chaparral thickets on heavy clay and loamy clay soils (Poole, 1985). Texas windmillgrass occurs along the Gulf Coast and throughout the northeastern Rio Grande Plains of Texas. It prefers silty and sandy loam soils and is known from Nueces County (Poole et al., 2000). Thieret's skullcap occurs on shell, sand, shell ridges, or sandy meadows usually not far from brackish marshes. It is also found growing in close association within woodlands

TABLE 3-4

ENDANGERED, THREATENED, PROPOSED, AND CANDIDATE SPECIES OF POTENTIAL OCCURRENCE IN THE PROJECT AREA COUNTIES[1]

Common Name[2]	Scientific Name[2]	Status[3] FWS	TPWD	NMFS	Likely Occurrence
PLANTS					
Black lace cactus	*Echinocereus reichenbachii albertii*	E	E	-	Unlikely
Slender rush-pea	*Hoffmannseggia tenella*	E	E	-	Unlikely
South Texas ambrosia	*Ambrosia cheiranthifolia*	E	E	-	Unlikely
Star cactus	*Astrophytum asterias*	E	E	-	Unlikely
Texas ayenia	*Ayenia limitaris*	E	E	-	Unlikely
Bailey's ballmoss	*Tillandsia baileyi*	SOC	-		Unlikely
Lilia de los llanos	*Echeandia chandleri*	SOC	-		Unlikely
Marshelder (slender) dodder	*Cuscuta attenuata*	SOC	-		Unlikely
Runyon huaco	*Manfreda longiflora*	SOC	-		May Occur - R
Runyon's water-willow	*Justicia runyonii*	SOC	-		Unlikely
Short-fruited spikerush	*Eleocharis brachycarpa*	SOC	-		Unlikely
Roughseed sea-purslane	*Sesuvium trianthemoides*	SOC	-		May Occur - R
Welder machaeranthera	*Psilactis heterocarpa*	SOC	-		May Occur - R
Texas windmill-grass	*Chloris texensis*	SOC	-		Unlikely
Thieret's skullcap	*Scutellaria thieretti*	SOC	-		Unlikely
INSECTS					
Maculated manfreda skipper	*Stalligsia maculosus*	SOC	-		Unlikely
Los Olmos tiger beetle	*Cincindela nevadica olmosa*	SOC	-		May Occur - R
MOLLUSCS					
Texas hornshell	*Popenaias popeii*	C_1	-	-	Unlikely
FISH					
Opossum pipefish	*Microphis brachyurus*	-	T	-	Unlikely
River goby	*Awaous tajasica*	-	T	-	Unlikely

TABLE 3-4 (Cont'd)

ENDANGERED, THREATENED, PROPOSED, AND CANDIDATE SPECIES OF POTENTIAL OCCURRENCE IN THE PROJECT AREA COUNTIES[1]

Common Name[2]	Scientific Name[2]	Status[3]			Likely Occurrence
		FWS	TPWD	NMFS	
Blackfin goby	*Gobionellus atripinnis*	-	T	-	Unlikely
Dusky shark	Carcharhinus obscurus			Candidate	Unlikely
Sand tiger shark	*Odontspis taurus*			Candidate	Unlikely
Night shark	*Carcharhinus signatus*			Candidate	Unlikely
Smalltooth sawfish	*Pristis pectinata*			Candidate	Unlikely
Largetooth sawfish	*Pristis perotteti*			Candidate	Unlikely
Speckled hind	*Epinephelus drummondhayi*			Candidate	Unlikely
Saltmarsh topminow	*Fundulus jenkinsi*			Candidate	Unlikely
Goliath grouper	*Epinephelus itajara*			Candidate	Unlikely
Warsaw grouper	*Epinephelus nitrigus*			Candidate	Unlikely
AMPHIBIANS					
Mexican treefrog	*Smilisca baudinii*	-	T	-	May Occur - LC
South Texas siren	*Siren* sp.[1]	-	T	-	Likely* - LC
Black-spotted newt	*Notophthalmus meridionalis*	SOC	T	-	Likely* - LC
White-lipped frog	*Leptodactylus labialis*	-	T	-	May Occur - LC
Sheep frog	*Hypopachus variolosus*	-	T	-	May Occur - LL
Rio Grande lesser siren	*Siren intermedia texana*	SOC	-		May Occur - LC
REPTILES					
Leatherback sea turtle	*Dermochelys coriacea*	E	E	E	May Occur - R
Atlantic hawksbill sea turtle	*Eretmochelys imbricata*	E	E	E	May Occur - R
Kemp's Ridley sea turtle	*Lepidochelys kempii*	E	E	E	May Occur - R
Loggerhead sea turtle	*Caretta caretta*	T	T	T	May Occur - R
Green sea turtle	*Chelonia mydas*	T	T	T	May Occur - R
American alligator	*Alligator mississipiensis*	T/SA	-	-	Unlikely
Texas tortoise	*Gopherus berlandieri*	-	T	-	May Occur - UC

TABLE 3-4 (Cont'd)

ENDANGERED, THREATENED, PROPOSED, AND CANDIDATE SPECIES OF POTENTIAL OCCURRENCE IN THE PROJECT AREA COUNTIES[1]

Common Name[2]	Scientific Name[2]	Status[3]			Likely Occurrence
		FWS	TPWD	NMFS	
Texas horned lizard	*Phrynosoma cornutum*	SOC	T	-	Likely - UC
Scarlet snake	*Cemophora coccinea*	-	T	-	Likely - R
Black-striped snake	*Coniophanes imperialis*	-	T	-	Likely - R
Indigo snake	*Drymarchon corais erebennus*	-	T	-	Likely - UC
Speckled racer	*Drymobius margaritiferus*	-	T	-	May Occur - R
Northern cat-eyed snake	*Leptoderia septentrionalis*	-	T	-	Likely - UC
Gulf salt marsh snake	*Nerodia clarkii*	SOC	-		Likely - UC
Texas diamondback terrapin	*Malaclemys terrapin littoralis*	SOC	-		Likely - UC
BIRDS					
Brown pelican	*Pelecanus occidentalis*	E	E	-	Likely* - LC
Northern aplomado falcon	*Falco femoralis septentrionalis*	E	E	-	Likely* - R
Whooping crane	*Grus americanus*	E	E	-	Unlikely
Eskimo curlew	*Numenius borealis*	E	E	-	Unlikely
Interior least tern	*Sterna antillarum athalassos*	E	E	-	Unlikely
Bald eagle	*Haliaeetus leucocephalus*	T	T	-	Unlikely
Piping plover	*Charadrius melodus*	T w/CH	T	-	Likely* - UC
Mountain plover	*Charadrius montanus*	P/T	-	-	Unlikely
American peregrine falcon	*Falco peregrinus anatum*	-	E	-	May Occur - R
Reddish egret	*Egretta rufescens*	SOC	T	-	Likely* - LC
White-faced ibis	*Plegadis chihi*	SOC	T	-	Likely* - C
Wood stork	*Mycteria americana*	-	T	-	Likely* - UC
Common black-hawk	*Buteogallus anthracinus*	-	T	-	Unlikely
White-tailed hawk	*Buteo albicadatus*	-	T	-	Likely* - UC
Zone-tailed hawk	*Buteo albonotatus*	-	T	-	Unlikely
Arctic peregrine falcon	*Falco peregrinus tundrius*	-	T	-	Likely* - R

TABLE 3-4 (Cont'd)

ENDANGERED, THREATENED, PROPOSED, AND CANDIDATE SPECIES OF POTENTIAL OCCURRENCE IN THE PROJECT AREA COUNTIES[1]

Common Name[2]	Scientific Name[2]	Status[3] FWS	TPWD	NMFS	Likely Occurrence
Sooty tern	*Sterna fuscata*	-	T	-	May Occur - R
Cactus ferruginous pygmy-owl	*Glaucidium brasilianum cactorum*	-	T	-	May Occur - UC
Northern beardless tyrannulet	*Camptostoma imberbe*	-	T	-	May Occur - R
Rose-throated becard	*Pachyramphus aglaiae*	-	T	-	Unlikely
Tropical parula	*Parula pitiayuma*	SOC	T	-	May Occur - R
Texas Botteri's sparrow	*Aimophila botterii texana*	SOC	T	-	Likely* - UC
Black tern	*Chidonias miger*	SOC		-	Likely* - C
Cerulean warbler	*Dendroica cerulea*	SOC		-	May Occur - UC
Loggerhead shrike	*Laneius ludovicianus*	SOC		-	Likely* - UC
Audubon's oriole	*Icterus graduacauda audubonii*	SOC	-		May Occur - UC
Brownsville common yellowthroat	*Geothlypis trichas insperata*	SOC	-		Unlikely - R
Ferruginous hawk	*Buteo regalis*	SOC	-		May Occur - UC
Sennett's hooded oriole	*Icterus cucullatus sennettii*	SOC	-		May Occur - UC
Texas olive sparrow	*Arremops rufivirgatus*	SOC	-		Likely* - C
Black rail	*Lacterallus jamaicensis*	SOC	-		May Occur - R
Northern gray hawk	*Buteo nitidus maximus*	SOC	-		Unlikely - UC
MAMMALS					
Ocelot	*Leopardus pardalis*	E	E	-	Likely* - R
Jaguarundi	*Herpailurus yagouaroundi*	E	E	-	Likely* - R
Jaguar (extirpated)	*Panthera onca*	E	E	-	Unlikely
West Indian manatee	*Trichechus manatus*	E	E	-	May Occur - R
Black bear	*Ursus americanus*	T/SA	T	-	Unlikely
Southern yellow bat	*Lasiurus ega*	-	T	-	May Occur - R
Coues' rice rat	*Oryzomys couesi*	-	T	-	May Occur - R

TABLE 3-4 (Concluded)

ENDANGERED, THREATENED, PROPOSED, AND CANDIDATE SPECIES OF POTENTIAL OCCURRENCE IN THE PROJECT AREA COUNTIES[1]

Common Name[2]	Scientific Name[2]	Status[3] FWS	TPWD	NMFS	Likely Occurrence
White-nosed coati	*Nasau nsrica*	-	T	-	May Occur - R
Maritime Texas pocket gopher	*Geomys personatus maritimus*	SOC	-		May Occur - UC

[1] Nomenclature follows Crother (2001), Hatch et al. (1990), Hubbs et al. (1991), AOU (1998), and Manning and Jones (1998).
[2] FWS - U.S. Fish and Wildlife Service.
TWPD - Texas Parks and Wildlife Department.
E - Endangered; in danger of extinction.
T - Threatened; severely depleted or impacted by man.
T/SA - Threatened due to similarity of appearance.
C - Species for which the FWS has on file enough substantial information to warrant listing as threatened or endangered.
DL - Formerly listed as threatened or endangered, but has been officially removed from threatened or endangered status.
P/T - Species proposed for listing as threatened
T w/CH - Species listed as threatened with proposed critical habitat in Texas
\- - Not listed.
SOC - Species of concern. Species for which there is some information showing evidence of vulnerability, but not enough data to suport listing at this time.
NMFS - National Marine Fisheries Service
* has been recorded in project area
A - Abundant
C - Common
UC - Uncommon
LC - Locally common
R - Rare

dominated by honey locust (*Gleditsia tricanthos*) and sugar hackberry *(Celtis laevigata*) in non-disturbed soils (Kral, 1983). These species are not likely to be found in the project area.

Roughseed sea-purslane occurs on dunes of south Texas (Correll and Johnston, 1970) and in brackish swales, marshes and depressions along the coast (Jones, 1977). Poole et al. (2000), show its range occurring only in Kenedy County. This species has a known population approximately 2 miles from the study area and within the Congressionally authorized boundaries of the PINS; hence, its occurrence in the project area is possible. Welder machaeranthera occurs in shrub-invaded grasslands and open mesquite-huisache woodlands on mostly gray clays to silty soils overlying the Lissie and Beaumont formations (Texas Organization for Endangered Species (TOES, 1993). It has been documented in both Kleberg and Nueces counties (Poole et al., 2000).

Bailey's ballmoss is an epiphyte found growing on various trees and shrubs in the South Texas brush country and in the lower Rio Grande Valley subtropical woodlands. Honey mesquite and live oak (*Quercus virginiana*) are common host trees to Bailey's ballmoss. It is doubtful that this species is found in the project area. Marshelder (slender) dodder is usually found in clays or various loams along floodplains parasitizing with two herbaceous weedy species; sumpweed (*Iva annua*) and giant ragweed (*Ambrosia trifida*) (TPWD, 2003). It flowers and fruits from mid-August until October and is closely related with another dodder (*Cuscuta indecora*), where both grow together creating yellow to orange densely tangled masses.

Runyon's huaco is found only in extreme south Texas including Cameron County. It inhabits openings in thorny shrublands on both clays and loams including soils with varying concentrations of salt, caliche, sand, and gravel (TPWD, 2003). It along with two other similar species (*Manfreda maculosa* and *M. sileri*) flower in September. It is possible that this species could be found within the project area on the mainland.

Runyon's water-willow is found in Cameron County on calcareous silty loams, clays and silty clays among woodlands and/or former floodplains. It is associated with sedge species (*Cyperus* spp.) and flowers September through November (TPWD, 2003). It is unlikely that this species would inhabit the project area.

Short-fruited spikerush is known only from one specimen collected in 1834 in south Texas by Berlandier and presumably in a wetland area (TPWD, 2003). Little information exists about this species and further surveys are sought for its distribution. It is unlikely that this sedge is found in the project area, although it is a possibility.

3.7.2 Wildlife

Table 3-4 also lists wildlife taxa that may occur in the project area that are considered by FWS and TPWD to be endangered or threatened. The table includes endangered and threatened species that have a geographic range which may include Nueces, Willacy, Kleberg, Kenedy, and/or Cameron counties. It should be noted that inclusion on the list does not imply that a species is known to occur in the project area, but only acknowledges the potential for occurrence. The following paragraphs present distributional data concerning each Federally or State-listed species, along with a brief evaluation of the potential for the species to occur within the project area.

3.7.2.1 Amphibians

Five amphibians are listed by the Texas Biological and Conservation Data Services (TXBCD) as potentially occurring within the project area. These species are listed as State-threatened and include the sheep frog (*Hypopachus variolosus*), black-spotted newt (*Notophthalmus meridionalis*), south Texas siren (*Siren* sp.), white-lipped frog (*Leptodactylus labialis*), and the Mexican treefrog (*Smilisca baudinii*). The sheep frog is rarely visible at the ground's surface. It is known to occur in shallow fishless ponds, in irrigation ditches, and under vegetative debris or rocks usually in grassy areas (Bartlett and Bartlett, 1999; TXBCD, 2002). This species has been recorded from all counties within the project area (Dixon, 2000). The white-lipped frog is dependent on standing water, such as irrigated fields, irrigation ditches, and ephemeral ponds, typically burrowing into the damp substrate (Bartlett and Bartlett, 1999). The Mexican treefrog is a large treefrog that can be found in resacas, irrigation canals, ponds, and roadside ditches (Bartlett and Bartlett, 1999). The white-lipped frog and Mexican treefrog are known to occur in Cameron County (Dixon, 2000). The black-spotted newt inhabits livestock ponds, ditches, resacas and other perennial, or nearly perennial waters, aestivating underground during dry periods (Bartlett and Bartlett, 1999; TXBCD, 2002). It has been recorded in each of the project area counties (Dixon, 2000). The south Texas siren requires some moisture, even during aestivation. It usually is found in ditches, resacas, or other perennial or semiperennial water bodies and is native south of the Balcones Escarpment (TXBCD, 2002). Although only the newt and the siren have been recorded in the project area (TXBCD, 2002), any of these amphibians could occur in mainland wetland sites within the project area.

The Rio Grande lesser siren is known to occur in the project area in habitat similar to that favored by the black-spotted newt. The Rio Grande lesser siren prefers warm, shallow waters with vegetative cover such as those in ponds, irrigation canals and swamps in permanently to semi-permanently inundated areas in counties along the lower coast of Texas and along the Rio Grande (Bartlett and Bartlett, 1999).

3.7.2.2 Birds

Twenty-five endangered, threatened, and rare bird species are listed by the FWS (2002a, b) and/or TPWD as occurring or potentially occurring in the project area (TXBCD, 2002). Several of these are predominantly inland species that are not ordinarily expected on the coast, or are migrants that pass through the region seasonally. Others may occur as breeding birds, permanent residents, or post-nesting visitors.

The Federally and State-endangered brown pelican (*Pelecanus occidentalis*), is primarily a coastal species that rarely ventures very far out to sea or inland. In Texas, it occurs primarily along the upper and middle coast nesting from Nueces to Galveston counties, but occasional sightings are reported south and east along the coast with few scattered records at reservoirs (FWS, 1995; TOS, 1995). This species is a common resident north of the project area and is likely to occur in the open-water habitat and sand/mud flats in the study area as a post-breeding visitor or migrant. It is considered an uncommon to locally common resident along the Texas Gulf Coast (TOS, 1995). Brown pelicans are locally common at some locations throughout the project area, particularly in the vicinity of Port Isabel.

The northern aplomado falcon (*Falco femoralis septentrionalis*) is listed as endangered by both the FWS and TPWD. This falcon is considered a rare summer resident of the Lower Rio Grande Valley and into the Trans-Pecos (TOS, 1995). Successful efforts have been made for the reintroduction of the aplomado falcon at more than a dozen sites from Calhoun County to Cameron County (The Peregrine Fund, 2002). This species inhabits savannahs and open woodlands, nesting on tall platforms, such as branches and utility poles, and often uses other raptors' nests (Hector, 1981; FWS, 1995).

Each year, the entire breeding population of whooping cranes migrates 2,600 miles from Canada's Northwest Territories and winters in the prairies, salt marshes and bays along the Texas coast. Rest areas along the migration route include the central and eastern panhandle of Texas (FWS, 1995). The Federally and State-endangered whooping crane has been recorded from counties within the project area as a migrant, but is generally restricted to the Aransas National Wildlife Refuge (NWR) in Aransas, Refugio, and Calhoun counties.

The current status of the Eskimo curlew (*Numenius borealis*) is considered uncertain and possibly extinct (TOS, 1995). One record does exist from Galveston, Texas, in 1962 and others since have been reported, but the validity of this report is uncertain (TOS, 1995). Migration of the Eskimo curlew once occurred in Texas from mid-March to late April (Oberholser, 1974). This species has been on the verge of extinction since the early 1900s and its current status is unknown.

The interior least tern (*Sterna antillarum athalassos*) is listed as endangered by the FWS and the TPWD. It is a rare local summer resident in the eastern panhandle of Texas and along the Red River, Colorado River and Rio Grande. Nesting usually occurs in small colonies on sand bars or sandy flats along rivers (Oberholser, 1974). The project area is considered to be within potential breeding range of the interior least tern (FWS, 1995). Least terns are known to occur in the project area, although the coastal subspecies is likely the one most frequently occurring.

The bald eagle (*Haliaeetus leucocephalus*) has recovered sufficiently to be downlisted to threatened throughout its range, and the FWS has proposed to completely delist the species in the near future (64 FR 36453-36363; July 6, 1999). Two subspecies are currently recognized based on size and weight: the northern bald eagle and the southern bald eagle. The northern population nests from central Alaska and the Aleutian Islands through Canada into the northern U.S. The southern population primarily nests in estuarine areas of the Atlantic and Gulf coasts, northern California to Baja California, Arizona and New Mexico (Snow, 1981). Wintering ranges of the two populations overlap. The bald eagle inhabits coastal areas, rivers and large bodies of water as fish and waterfowl comprise the bulk of their diet. Nests are seldom far from a river, lake, bay, or other water body. Nest trees are generally located in woodlands, woodland edges, or open areas, and are frequently the dominant or co-dominant tree in the area (Green, 1985). The 2001 bald eagle nesting survey in Texas identified 117 nesting territories statewide, the southernmost found in Refugio, Goliad, Victoria, and Matagorda counties (Ortego, 2001). Concentrations of wintering northern eagles are often found around the shores of reservoirs in Texas, with most wintering concentrations occurring in the eastern part of the state. Although Oberholser (1974) shows a wintering record for Cameron County, the current distribution of wintering bald eagles in Texas does not extend into the project area (FWS, 1995). No nests are known to occur in the study area, nor have any been reported from the project area counties (Ortego, 2001). Any bald eagle occurring in the project area would be considered a rare migrant or post-nesting visitor.

The Federally and State-threatened piping plover is a winter resident and spring and fall migrant of the project area. This small shorebird breeds in the northern Great Plains of the U.S. and Canada, along beaches of the Great Lakes, and along the Atlantic coastline from North Carolina to Newfoundland (Haig and Oring, 1987). Post-breeding and wintering sites include the southern U.S. Atlantic coastline; the Gulf of Mexico from Florida to Veracruz, Mexico; and on scattered Caribbean islands (Haig and Oring, 1985). The piping plover can be found along Texas beaches and tidal flats from mid-July through April. The USACE has sponsored several studies to locate piping plovers and their habitat and evaluate the effects of dredged material placement on the ecology of the piping plover (EH&A, 1993, 1997b; Zonick et al., 1998; Drake et al., 1999). Efforts were focused on understanding how plovers use coastal habitats and react to the placement or removal of placement areas. Wintering ground Critical Habitat for the piping plover has been designated within the project area and adjacent areas as shown on Figure 3-3. Existing placement areas coincide with critical habitat reaches 2 through 6.

The mountain plover (*Charadrius montanus*) was proposed for listing as a Federally threatened species on February 16, 1999 (64 FR 7587). Non-breeding birds prefer short-grass plains, fields, plowed fields, sandy deserts, and sod farms (NatureServe, 2000) and are known to frequent salt flats and coastal prairies without venturing too close to the water (Oberholser, 1974; TOS 1995). The mountain plover is a rare to uncommon local winter resident on the coastal plains and inland from south Texas through the Edwards Plateau into the South Plains (TOS, 1995). The mountain plover has been recorded from Nueces, Kleberg, and Cameron counties (Oberholser, 1974). Although this species has been recorded on the coastal mainland, it is absent from checklists for Mustang Island State Park (Pulich et al., 1985) and PINS (SPMA, 1990). This species is unlikely to occur within the project area.

All North American peregrine falcons were delisted from the endangered species list (64 FR 46541–46558, August 2, 1999). The American peregrine falcon (*Falco peregrinus anatum*) remains on the State endangered list. It is known to nest in the mountains of the Trans-Pecos region of Texas. It could occur as a migrant within the project area. The Arctic peregrine falcon (*Falco peregrinus tundrius*), which was listed as endangered due to similarity of appearance (E/SA) was delisted Federally but remains on the TPWD threatened list. The Arctic peregrine falcon winters along the entire Gulf Coast and occurs statewide during migration (FWS, 1995).

The white-faced ibis (*Plegadis chihi*) is a common resident along the coast. This species is State-listed as threatened. Preferred habitats of the white-faced ibis have been described as ranging from freshwater marshes and sloughs and irrigated rice fields to salt marshes (Oberholser, 1974). The reddish egret, another State-threatened species, typically inhabitants saltwater bays and marshes. Its

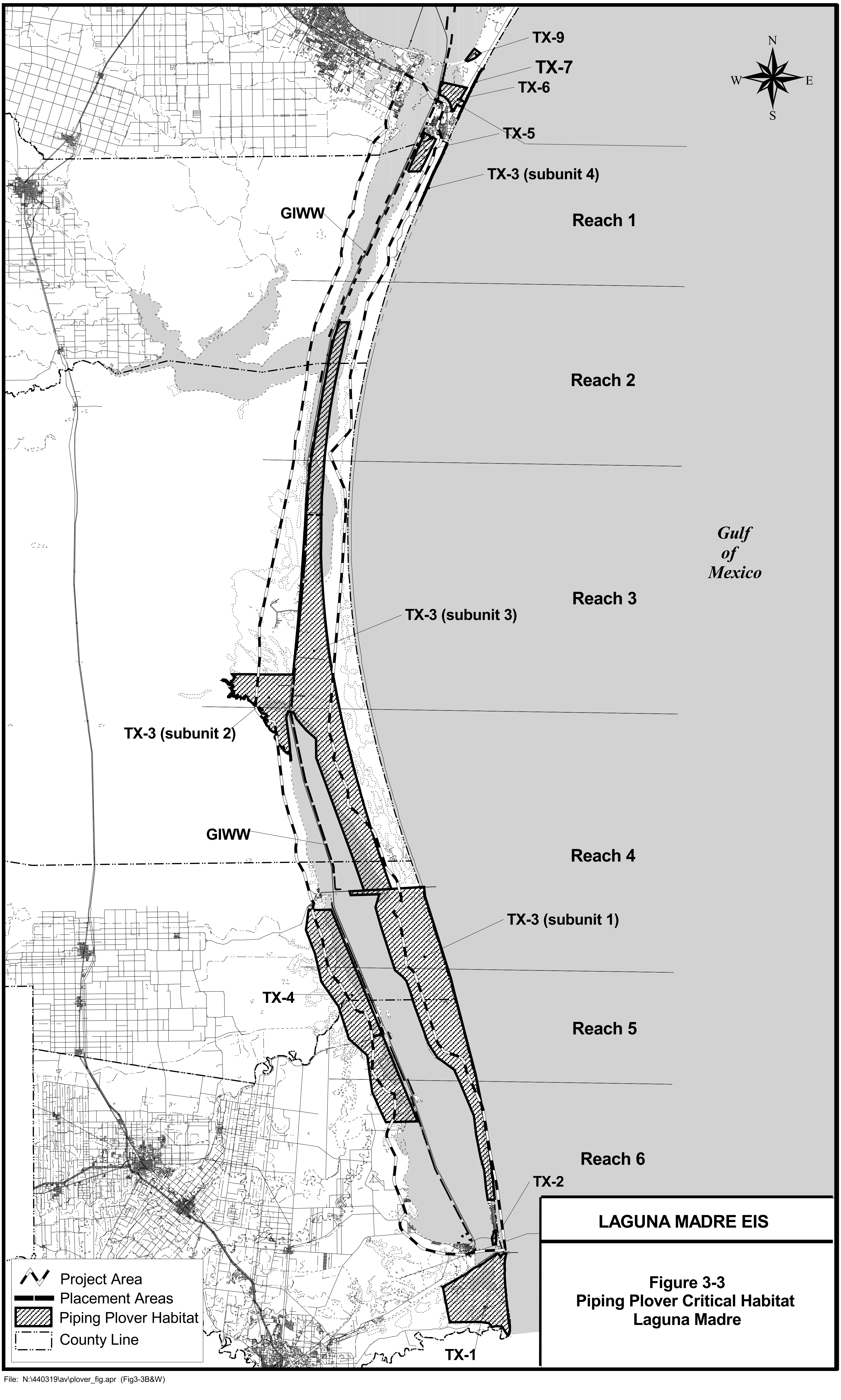

Figure 3-3
Piping Plover Critical Habitat
Laguna Madre

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breeding range is restricted to the Gulf coast where it commonly nests in yucca-prickly pear thickets (Oberholser, 1974). Both of these species nest within the project area.

The wood stork (*Mycteria americana*) is listed as a threatened species by TPWD. This bird is an uncommon to common post-breeding visitor to the central and upper coastal prairies and a regular visitor of lakes and reservoirs in central and east Texas. This species has been recorded within Nueces and Cameron counties (Oberholser, 1974; TOS, 1995). The wood stork is commonly seen near freshwater habitats in PINS (SPMA, 1990).

The State-threatened common black-hawk is described as very rare in the lower Rio Grande Valley (TOS, 1995). According to Oberholser (1974), the last confirmed nesting of this species in the Lower Rio Grande Valley occurred in Cameron County in 1937, and breeding populations have probably been extirpated in the area due to desiccation of the valley. Breeding birds formerly occurred in willow groves along the Rio Grande floodplain in southern Starr, Cameron, and Hidalgo counties. Oberholser (1974) lists its most recent sightings in coastal prairie of the Laguna Madre.

The white-tailed hawk (*Buteo albicaudatus*), is listed as State-threatened and is considered an uncommon local resident along the Texas coastal plain (TOS, 1995). The white-tailed hawk inhabits mesquite live oak savannah inland and coastal grasslands, such as the saltgrass flat found within the project area (Oberholser, 1974). The white-tailed hawk appears on the bird checklist for PINS as uncommon in grasslands throughout the year (SPMA, 1990).

The State-threatened zone-tailed hawk is a rare to uncommon breeding bird in the Trans-Pecos and Edwards Plateau regions of Texas (Oberholser, 1974). Observations of zone-tailed hawk have been reported in Hidalgo County, but there are no verified breeding records (Oberholser, 1974). The zone-tailed hawk, a mesa- and canyon-inhabiting species, is unlikely to occur in the project area.

The sooty tern (*Sterna fuscata*) is considered a rare local summer resident along the central and lower coast (TOS, 1995). This pelagic bird spends almost its entire life at sea. Many records have been reported on the Texas coast following large tropical storms. FWS (2002c) show several isolated breeding records for this species within the project area over the past 30 years. This State-threatened species is a rare, but potential, vagrant to the project area.

One rare owl, the cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*) is a denizen of woodlands and shrublands in south Texas ranging from the Lower Rio Grande Valley north into Kenedy County (Oberholser, 1974; TOS, 1995). Ferruginous pygmy-owls may occur in the project area where suitable brushland habitat is present. Currently, the cactus ferruginous pygmy-owl is listed as a State-threatened species.

The northern beardless-tyrannulet (*Camptostoma imberbe*) is a small flycatcher found mostly in mesquite and riverine thickets. The rose-throated becard (*Pachyramphus aglaiae*) is a medium-sized flycatcher usually found frequenting riparian groves of large trees (especially Montezuma baldcypress and black willow). The tropical parula (*Parula pitiayumi*) nests in bottomland forests, selecting sites where its nesting materials, primarily Spanish moss (*Tillandsia usneoides*) and the gray-green lichen (*Usnea* sp.), are epiphytic on oaks and other trees (Oberholser, 1974; TOS, 1995). These species are listed by the State as threatened. Tropical parula and northern beardless tyrannulet have both occurred at LANWR and at various locations along the mainland side of the Laguna Madre in Willacy and Kenedy counties; however, the limited amount of suitable habitat for either species within the study area would limit their presence in the project area to occasional, rare occurrences during migration and/or post-breeding dispersal. Their presence on dredge material islands would be limited to those islands having large trees or mottes. Almost all of the Texas records of rose-throated becard are from Hidalgo County, where it is a rare winter visitor. The species has been recorded in Kenedy County, but has not been recorded at either LANWR or PINS (FWS, 1987; SPMA, 1990; TOS, 1995). The likelihood of this species occurring within the project area is very low.

The Texas Botteri's sparrow (*Aimophila botterii texana*) is an uncommon to locally common summer resident on the lower coastal plain from Kenedy County south to Cameron County, with isolated breeding records from Duval, Jim Wells, and San Patricio counties (TOS, 1995). This sparrow is an inhabitant of tall bunch grass prairie with widely scattered shrubs and small trees mostly within 20 miles of the Gulf coast (Oberholser, 1974). The reason for a decline in numbers of this species is attributed mostly to depletion of habitat due to agriculture practices (Oberholser, 1974). TPWD considers this sparrow to be threatened.

Two *Buteo* species, northern gray hawk (*Buteo nitidus maximus*) and ferruginous hawk (*Buteo regalis*), are considered SOC by the FWS. The northern gray hawk is a rare to uncommon local resident in the Lower Rio Grande Valley (TOS, 1995). In Texas, this hawk inhabits mature woodlands of the river valleys and nearby semiarid mesquite and scrub grasslands (Oberholser, 1974). Oberholser (1974) shows a fall record of the northern gray hawk from Nueces County and records exist from Kleberg County; however, this species is unlikely to occur in the project area. The ferruginous hawk ranges the wide open spaces of the dry Great Plains and Great Basin in western North America (Oberholser, 1974). It may occur in the project area as a migrant or winter resident. It is considered locally uncommon on Texas' barrier islands and the central and south coastal plains (TOS, 1995).

Three additional avian SOC of potential occurrence in the study area include the black rail (*Laterallus jamaicensis*), black tern (*Chlidonias niger*), and loggerhead shrike (*Lanius ludovicianus*). The black rail is a rare migrant and winter resident in the state (Oberholser, 1974) and may potentially occur in the northern part of the project area. It is primarily a bird of coastal marshes, typically dominated by smooth cordgrass. The black tern is a common migrant in all parts of Texas including offshore waters (TOS, 1995). It breeds in marshy areas of the northern United States and Canada, and migrates through Texas during all months except January, February, and March (Oberholser, 1974). This species occurs within the project area. The loggerhead shrike is an inhabitant of open country with scattered trees and shrubs. It is a rare to common resident throughout the state, except for portions of the South Texas Plains. It is a possible resident/migrant within the project area.

Five songbirds of potential occurrence within the project area are considered SOC by the FWS. These five species are: cerulean warbler (*Dendroica cerulea*), Texas olive sparrow (*Arremonops *rufivirgatus*), Sennett's hooded oriole (*Icterus cucullatus sennettii*), Audubon's oriole (*Icterus graduacada audubonii*) and Brownsville common yellowthroat (*Geothlypis trichas insperata*).

The cerulean warbler is a rare to uncommon spring migrant in the eastern half of the state, mostly on the coast, and south to the Rio Grande Valley (TOS, 1995) and prefers deciduous or mixed woodlands near stream bottoms. It may occur within the project area only during spring migration. The olive sparrow is a common resident in south Texas, extending north to Goliad, Karnes, Uvalde, and Val Verde counties (TOS, 1995). This sparrow inhabits dense brushy areas where it spends much of its life on or near the ground. This species is unlikely to inhabit the project area, due to lack of appropriate habitat.

Sennett's hooded oriole is a summer resident and rare winter resident in south Texas. It inhabits areas closely associated with towns where it nests in palm (*Washingtonia* sp. and *Sabal* sp.) and pecan (*Carya illinoinensis*) trees (Oberholser, 1974). Audubon's oriole is a rare to uncommon resident in south Texas and is typically found in wooded or brushy areas. During the warmer months, it tends to prefer mesquite woodlands; in winter it can be found in evergreen trees such as live oak (*Quercus virginiana*) along with huisache (*Acacia smallii*) and Texas ebony (*Pithecellobium flexicaule*) (Oberholser, 1974). Both species of oriole may occur in the project area. The Brownsville common yelowthroat is a resident of the Rio Grande Delta below Brownsville. It is known from Cameron County, however, little information exists on its distribution elsewhere. It is doubtful that the Brownsville common yellowthroat would occur within the study area.

3.7.2.3 Fish

A candidate species is a candidate for listing under the ESA. More specifically, it is a species or vertebrate population for which sufficient reliable information is available that a listing under the ESA may be warranted. There are no mandatory Federal protections required under the ESA for a candidate species (NMFS, 2001).

The dusky shark (*Carcharhinus obscurus*), also known as the bronze whaler or black whaler, was added to the NMFS candidate species list in 1997. It has a wide-ranging (but patchy) distribution in warm-temperate and tropical continental waters (NMFS, 2001). It is coastal and pelagic in its distribution where it occurs from the surf zone to well offshore and from surface depths to 1,312 feet (Compagno, 1984). Because it apparently avoids areas of lower salinities, it is not commonly found in estuaries (Compagno, 1984; Musick et al., 1993).

The Atlantic and Gulf of Mexico populations of the sand tiger shark (*Odontspis taurus*) were added to the candidate species list in 1997. Sand tiger sharks have a broad inshore distribution. In the western Atlantic, this shark occurs from the Gulf of Maine to Florida, in the northern Gulf of Mexico, in the Bahamas and in Bermuda. Although first reported in Texas in the 1960s, this species does not seem to be uncommon. A cool temperate species, it is more common north of Cape Hatteras (Hoese and Moore, 1998). It is generally coastal, usually found from the surf zone down to depths around 75 feet. However, they may also be found in shallow bays, around coral reefs and to depths of 600 feet on the continental shelf. They usually live near the bottom, but may also be found throughout the water column (NMFS, 2001).

NMFS designated the night shark (*Carcharhinus signatus*) a candidate species in 1997. Data on this species are minimal because the night shark is a deepwater shark. This shark has been reported in waters from Delaware south to Brazil, including the Gulf of Mexico. It has also been reported from West Africa. It was formerly abundant in deep waters off the northern coast of Cuba and the Straits of Florida (NMFS, 2001).

The smalltooth sawfish (*Pristis pectinata*) and largetooth sawfish (*Pristis perotteti*) were added to the candidate species list in 1991, removed in 1997, and placed back on the list again in 1999. Smalltooth sawfish have been reported in both the Pacific and Atlantic oceans, but the U.S. population is found only in the Atlantic. Historically, the U.S. population was common throughout the Gulf of Mexico from Texas to Florida, and along the east coast from Florida to Cape Hatteras. The current range of the smalltooth sawfish is limited to peninsular Florida, and it is relatively common only in the Everglades region at the southern tip of the state. They are often found in shallow water of inshore bars, mangrove edges, and seagrass beds, occasionally found in deeper coastal waters. Largetooth sawfish have been reported mainly along the Texas coast and east into Florida waters, but reported occurrences of this species in U.S. waters are very rare. It has been noted that all specimens reported from the coast of Texas have been large, in contrast with the abundance of smaller ones further south, suggesting that the production of young is confined chiefly to southern regions where the temperature of the water is at least as high as 25–26°C (77–78.8°F). They are often found in brackish water near river mouths and large embayments, preferring partially enclosed waters, lying in deeper holes on bottom of mud or muddy sand (NMFS, 2001).

The speckled hind (*Epinephelus drummondhayi*) inhabits warm, moderately deep waters from North Carolina to Cuba, including Bermuda, the Bahamas and the Gulf of Mexico. Their preferred habitat is hard bottom reefs in depths ranging from 150 to 300 feet, where the temperatures are from 60 to 85°F. The speckled hind was added to the candidate species list in 1997 (NMFS, 2001).

NMFS designated the saltmarsh topminnow (*Fundulus jenkinsi*) as a candidate species in 1997. This rare species is restricted to coastal streams and adjacent bay shores on the western side of Galveston Bay and from Vermilion Bay to the Florida Panhandle. Usually found in low salinities, it has been taken from the Chandeleur Islands (Hoese and Moore, 1998). This species tends to live in salt marshes and brackish water, although it has been known to survive in freshwater. This species can also be found in shallow tidal meanders of cordgrass marshes (NMFS, 2001).

The goliath grouper (*Epinephelus itajara*), formerly named the jewfish, was added to the candidate species list in 1991 for the region of North Carolina southward to the Gulf of Mexico, which encompasses the entire range of this species in U.S. waters. Historically, goliath grouper were found in tropical and subtropical waters of the Atlantic Ocean, both coasts of Florida, and from the Gulf of Mexico down to the coasts of Brazil and the Caribbean. They were abundant in very shallow water, often associated with piers and jetties along the Florida Keys and southwest coast of Florida (NMFS, 2001).

The Warsaw grouper (*Epinephelus nitrigus*) was added to the candidate species list in 1997. It is a very large fish found on the deepwater reefs of the southeastern United States. Warsaw grouper range from North Carolina to the Florida Keys and throughout much of the Caribbean and Gulf of Mexico to the northern coast of South America. The species inhabits deepwater reefs on the continental shelf break in waters 350 to 650 feet deep. As for all of the candidate species above, the main threat to them has been mortality associated with fishing (NMFS, 2001).

The TXBCD files include three State-threatened fish which may potentially occur in the project area. The river goby (*Awaous tajasica*) is known from the Atlantic and Gulf coasts of the U.S. In Texas, this species is known only from Hidalgo and Willacy counties, however it is very rare in the Rio Grande apparently reaching the northern edge of its distribution in this stream (Hubbs et al., 1991; Hoese and Moore, 1998; HARC and ITESM, 2000). Habitat includes lakes, ponds, rivers and streams, brackish and estuarine areas, occurring only in brackish water in seasonally intermittent streams (Watson, 1996). The blackfin goby (*Gobionellus atripinnis*) has only been reported from the Rio Grande near Brownsville. It is known to occur in brackish and freshwater habitats but has only been found in coastal freshwater streams (Hoese and Moore, 1998). The opossum pipefish (*Microphis brachyurus*) has been only been reported from the lowermost reaches of the Rio Grande in Cameron County (Hubbs et al., 1991). Habitat includes freshwater streams, rivers, and estuaries. Juveniles are usually found in estuaries while adults are found upstream in freshwater areas (Dawson, 1985).

3.7.2.4 Mammals

Eight mammal species are considered to be endangered or threatened in the project area counties by FWS and/or TPWD.

The ocelot (*Leopardus pardalis*) and jaguarundi (*Herpailurus yagouaroundi*) are listed by FWS and TPWD as endangered. The ocelot is a medium-sized cat which ranges from southern Texas and Arizona to northern Argentina (Campbell, 1995). According to Campbell (1995), the ocelot prefers habitat described as thornscrub with a dense canopy cover. Ocelots have been known to prey on small mammals, birds, reptiles, amphibians and some fish (Davis and Schmidly, 1994). The jaguarundi occurs in south Texas, east and western portions of Mexico, and south into South America (Hall, 1981). In Texas, this cat inhabits very similar habitat as described for the ocelot, very dense thornscrub (Davis and Schmidly, 1994). Both of these cat species are included on TPWD's Special Species List as potentially occurring in the counties in which the project area occurs. It is quite possible that jaguarundis and ocelots inhabit upland thorn-scrub habitats in mainland reaches of the project area, as it is known from LANWR (FWS, 2002d). The jaguar (*Panthera onca*) was once fairly common over southern Texas into Louisiana and north to the Red River (Davis and Schmidly, 1994). Presently, the jaguar has been considered extirpated from the state with the last record of this large cat occurring at the turn of the century (Davis and Schmidly, 1994).

The West Indian manatee (*Trichechus manatus*) is a Federally and State-listed endangered aquatic mammal which inhabits brackish water bays, large rivers, and salt water (Davis and Schmidly, 1994). It feeds upon submergent, emergent, and floating vegetation with the diet varying according to plant availability (O'Shea and Ludlow, 1992). The manatee is more common in the warmer waters off of coastal Mexico, the West Indies, and Caribbean to northern South America (NatureServe, 2000). In the U.S., populations are primarily found in Florida, but occasional vagrants migrate along the coast into Texas. Although extremely rare in Texas, recent Texas records include specimens from Cameron, Galveston, Matagorda, and Willacy counties (FWS, 1995). Records of sightings by the Texas Marine Mammal Stranding Network (Price-May, 2002) include: summer 1994 in the Arroyo Colorado; August 1995 at Mansfield Pass; October 1995 at Port Mansfield area; and October–November 1995 near the Naval Air Station at Corpus Christi. Davis and Schmidly (1994) describe a record of a manatee which was found dead in the surf near the Bolivar Peninsula near Galveston, Texas. Albert Oswald of the Texas State Aquarium in Corpus Christi, Texas, spotted a manatee in the inlet between the Texas State Aquarium and the Lexington Museum on 23 September 2001. This is the third and probably most reliable recent sighting of the manatee in Corpus Christi Bay (Beaver, 2001). While the West Indian manatee has been sighted in Corpus Christi Bay and the Laguna Madre, such occurrences are uncommon.

The black bear (*Ursus americanus*) is listed as threatened by TPWD and threatened due to similarity of appearance (T/SA) to other protected bear species by the FWS. This species was formerly widespread throughout the state, but is now restricted mainly to mountainous areas of the Trans-Pecos region (Davis, 1974). Within the Trans-Pecos and southern Edwards Plateau regions, it appears that black bear populations are increasing, possibly due to the closure of the bear hunting season in Mexico in 1986. The majority of bear sightings have come from west Texas. Several reports have come from central Texas in northern portions of Val Verde County along the Pecos river (Taylor, 1996). Black bears are more common in Mexico but an occasional vagrant may occur in south Texas. This species is not likely to occur within the project area.

The southern yellow bat (*Lasiurus ega*) is a neotropical bat that is listed as State-threatened. In the U.S., this bat has been recorded from southern California, southern Arizona, extreme southwestern New Mexico and south Texas (Schmidly, 1991). In Texas, the southern yellow bat occurs in the extreme south where it utilizes trees as roosting sites. In some areas of south Texas, palm trees appear to be preferred roosting sites (Davis and Schmidly, 1994).

The Coues' rice rat (*Oryzomys couesi*) is considered a Mexican species whose northernmost range extends into south Texas in Cameron and Hidalgo counties (Davis, 1974). This species has been captured in cattail-bulrush marshes and aquatic grassy zones near oxbow lakes in Hidalgo County (Davis and Schmidly, 1994). Habitat for the rice rat is composed primarily of brushlands with access to water. This species is considered State-threatened.

The State-threatened white-nosed coati (*Nasua narica*) is known to occur in wooded areas of Central America, Mexico and south Texas. According to Davis and Schmidly (1994), these animals spend a considerable amount of time on the ground but are well adapted for climbing trees. The habitats of the coati in south Texas ranges from dense woodlands to rocky canyons. Davis (1974) includes south Texas within the distribution of the white-nosed coati and cites reports of this species in riparian woodlands. Coatis are more likely to occur within the Rio Grande floodplain in the southern part of the project area.

The maritime Texas pocket gopher (*Geomys personatus maritimus*), a Federal SOC, is known from Kleberg and Nueces counties (TOES, 1995; TXBCD, 2002). It inhabits areas with deep, sandy soils where it constructs its burrows and tunnels. It is a possible resident of the project area.

3.7.2.5 Reptiles

Five sea turtles are Federally and State endangered within the project area counties. These sea turtles include the loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), Atlantic hawksbill sea turtle (*Eretmochelys imbricata*), and Kemp's ridley sea turtle (*Lepidochelys kempii*). These sea turtles are known to occur in the Gulf of Mexico, including associated bay and estuarine waters and sometimes nest along the Gulf beaches (Garrett and Barker, 1987). It is a possibility for any of these species to be observed within the project area.

Leatherback sea turtles are considered to be the most pelagic of the sea turtles, seldom approaching land except for nesting. They are mainly found in coastal water only when nesting and when following concentrations of jellyfish, which is the principal food source (TPWD, 2000; FWS, 1995; Garrett and Barker, 1987). The leatherback nests on sandy, sloping beaches, often near deepwater and rough seas (NMFS and FWS, 1992). The largest nesting beaches are found in the U.S. Virgin Islands, Puerto Rico, and Florida (NMFS, 2000). This species has been recorded in Nueces, Kenedy, and Cameron counties (Dixon, 2000).

The Atlantic hawksbill sea turtle is found in rocky bottom, shallow, coastal water areas, lagoons, estuaries, and mangrove-bordered bays in water generally less than 60 feet deep (FWS, 1995). This species prefers foraging habitat of coral reefs, rocky outcrops, and high energy shoals, which are optimum sites for sponge growth, as sponges are one of their principal food sources. Other forage foods include crabs, sea urchins, shellfish, jellyfish, plant material, and fishes. Nesting activities may include deep sand beaches of low energy to high energy beaches. Nesting in the Continental U.S. is limited to the southeast coast of Florida, Florida Keys, Puerto Rico, and U.S. Virgin Islands. Most of the Texas sightings involve posthatchlings and juveniles which are primarily associated with stone jetties and originated from nesting beaches in Mexico (NMFS, 2000). The Atlantic hawksbill sea turtle has been recorded in Nueces, Kleberg, Willacy, and Cameron counties (Dixon, 2000).

The Kemp's ridley sea turtle is known to inhabit shallow coastal and estuarine waters usually over sand or mud bottoms where a food source of crabs can be found (FWS, 1995). Other food items include shrimp, snails, bivalves, sea urchins, jellyfish, sea stars, fish, and occasional marine plants (Campbell, 1995). Nesting activities are essentially restricted to the Gulf of Mexico at Rancho Nuevo, Tamulipas, Mexico. Sporadic nesting has been reported from Mustang Island, Texas, southward to Isla Aquada, Campeche, Mexico (NMFS, 2000; Hildebrand, 1983, 1986, 1987). This species has been recorded in all five project area counties (Dixon, 2000). Kemp's ridley have been observed mating in the Port Mansfield Channel and, thus, could potentially mate in the nearby Laguna Madre.

The loggerhead sea turtle is widely distributed within its range. It can be found in waters hundreds of miles offshore as well as inshore areas such as bays, lagoons, salt marshes, ship channels, and mouths of large rivers (FWS, 1995). This species feeds on various marine invertebrates – crustaceans, mollusks, sponges, echinoderms, gastropods and some plants, fish, and jellyfish. They nest on high energy beaches on barrier islands with steeply sloped beaches and gradually sloped offshore approaches. The nesting range in the U.S. is mainly the Atlantic Coast, although nesting on barrier islands along the Texas coast has been recorded (NMFS and FWS, 1991a; Shaver, 2000). The loggerhead sea turtle has been recorded in all project area counties (Dixon, 2000).

The green sea turtle's favored habitat appears to be lagoons and shoals with an abundance of marine grasses and algae (FWS, 1995). The adults are primarily herbivorous while the juveniles consume more invertebrates. Foods consumed include SAV, macroalgae and other marine plants, mollusks, sponges, crustaceans, and jellyfish (Mortimer, 1982). Terrestrial habitat is typically limited to nesting activities on deep, coarse to fine sands with little organic content, along high energy beaches. Major nesting activity occurs in Costa Rica and Surinam with small numbers nesting in Florida and rarely in Texas, Georgia and North Carolina (NMFS and FWS, 1991b). This species has been recorded in Nueces, Kleberg, Kenedy, and Cameron counties (Dixon, 2000).

The American alligator (*Alligator mississippiensis*) was first Federally listed as endangered in 1967 because hunting and poaching had substantially reduced its numbers. It was reclassified as threatened in certain parts of Texas in 1977 because of partial recovery. In 1983, it was further reclassified in Texas as threatened due to similarity of appearance (T/SA) reflecting complete recovery of the species in the state. Thus, in Texas, the alligator is no longer biologically threatened or endangered, but because of the similarity of appearance of its hides and parts to those of protected crocodilians elsewhere, it is necessary to restrict commercial activities involving alligators taken in Texas to safeguard against excessive harvesting, and to ensure the conservation of other crocodilians that are still biologically threatened or endangered. The American alligators preferred habitat includes broad river valleys, streams, oxbow lakes, marshes, swamps, estuaries, bayous, and creeks with minimal water flow where they feed on a variety of aquatic and terrestrial prey. The American alligator has been recorded in Nueces and Cameron counties (Dixon, 2000). The potential for this species to occur within the project area is low.

Five snakes that are listed as endangered or threatened by the TPWD, but not by the FWS, may occur in the project area. These are the black-striped snake (*Coniophanes imperialis imperialis*), northern cat-eyed snake (*Leptodeira septentrionalis septentrionalis*), Texas indigo snake (*Drymarchon imperialis imperialis*), speckled racer (*Drymobius margaritiferus*) and scarlet snake (*Cemophora coccinea*) (TXBCD, 2002).

The black-striped snake is a denizen of subtropical chaparral and remnant deciduous woodlands that once covered deep south Texas. They can also be found under debris and leaf litter near human habitations. The northern cat-eyed snake inhabits subtropical thornscrub and deciduous woodlands bordering ponds and streams. The Texas indigo snake is most common in thorn brush woodland in riparian corridors and in mesquite savannah. The speckled racer occupies dense remnants of subtropical forest with a heavily littered plant debris substrate near ditches and swamps in Cameron County and south to coastal Mexico. Near the Gulf coast, the scarlet snake is found in thickets of various vegetative cover on loose sandy substrates (Werler and Dixon, 2000). All of these species are likely to occur in the project area, but the northern cat-eyed snake and the Texas indigo snake are more probable than the speckled racer or scarlet snake, which have highly restricted habitat requirements.

The Texas tortoise (*Gopherus berlandieri*) is listed as a threatened species by the TPWD. This species is confined to arid south Texas and northeastern Mexico. It is active in hot weather, and it has the potential for occurrence in the project area (Conant and Collins, 1991). The Texas tortoise prefers thorn-scrub and desert grassland habitats with sandy soils (Bartlett and Bartlett, 1999). This species is not Federally listed, but is considered threatened in Texas by the TPWD. In appropriate habitat, this species may occur within the project area. The Texas horned lizard was historically found throughout the state in areas with flat, open terrain, scattered vegetation, and sandy or loamy soils. Over the past 20 years, it has almost vanished from the eastern half of the state, but still maintains relatively stable numbers in west Texas (Bartlett and Bartlett, 1999). This species has been recorded from counties within the project area (Dixon, 2000) and may occur within the project area.

In addition, the Gulf salt marsh snake (*Nerodia clarkii*) is considered a SOC by the FWS (2002b). The Gulf salt marsh snake inhabits crayfish and fiddler crab burrows in the saltgrass-lined margins of tidal mud flats (Garrett and Barker, 1987). This species is shown to be outside of its range in Nueces County by Dixon (2000), yet the FWS (2002b) indicates Nueces County to be within its range. Habitat for the Gulf salt marsh snake is present in the project area, thus there is potential for its occurrence.

The Texas diamondback terrapin (*Malaclemys terrapin littoralis*) is identified as a SOC by the FWS (2002b) in Nueces County. This species occurs from the Texas-Louisiana border south to Nueces County (Dixon, 2000). The Texas diamondback terrapin is the only turtle in the world entirely restricted to estuarine habitat, where it lives in coastal marshes, tidal mud flats, and tidal creeks (Garrett and Barker, 1987). This species is likely to occur in the project area.

3.7.2.6 Mollusks

The Texas hornshell (*Popenaias popeii*) is considered a candidate for listing by the FWS. This mollusk has a limited distribution in Texas with known occurrences from the Rio Grande River to the Pecos River, San Francisco Creek in the Big Bend area, the Devils River, and the Rio Salado in Mexico (Howells et al., 1996). Although little information is available for this species, Howells et al. (1996) consider loss of habitat combined with a deterioration in water quality to have contributed to the decline of the Texas hornshell. It is very unlikely for this freshwater species to occur in the Laguna Madre due to the high salinity of this water body.

3.7.2.7 Insects

Two insect species, the maculated manfreda skipper (*Stallingsia maculosa*) and Los Olmos tiger beetle (*Cincindela Nevada*) are listed as SOC by the FWS. Manfreda skipper is a rare butterfly known from several south Texas counties and northern Mexico. The FWS (2002b) identifies this species as a SOC in Nueces and Kleberg counties. The larvae of this species are closely associated with Texas tuberose (*Manfreda maculosa*) which grows on prairies and chaparral covered hills of the Rio Grande Valley and Plains (Correll and Johnston, 1970; Tilden and Smith, 1986). Its presence in the project area is unlikely.

The Los Olmos tiger beetle, a Federal SOC known to occur in Kenedy County, commonly inhabits both saline and non-saline habitats in close association with water. Specifically, its habitat may be described as white alkali sands on the banks of creeks or among the small burrows of salt flats (BISON, 2003). Its presence in the project area is possible due to the presence of moist saline soils.

3.8 HAZARDOUS, TOXIC AND RADIOACTIVE WASTES (HTRW)

In July 1995, a comprehensive HTRW study (EH&A, 1995) was conducted to identify indicators of potential hazardous materials or waste issues under Section 216 study authority (Section 216 of the Flood Control Act of 1970) relating to the GIWW from Corpus Christi to Port Isabel and including the Laguna Madre.

The agency files reviewed indicated that several regulated facilities, reported spills, considerable past and present oil and gas exploration/production sites, and petroleum pipeline crossings occurred in or adjacent to the Laguna Madre (see EH&A, 1995, for details). Considering the nature of these sites and the lack of commercial or industrial development, the most likely source of contamination to the project area would be associated with active oil/gas wells or petroleum pipelines. While petroleum is not classified as a hazardous waste, it is included here because a pipeline or well could be a hindrance to a project and petroleum spills could cause impacts. Typical releases would be from leaks or spills of condensate, or distillate, derived from the natural gas itself. In general, only a few gallons of distillate would be expected to form from several hundred to thousands of cubic feet of natural gas pumped or transferred via pipeline. Because hydrocarbon products will float on the water's surface, there is very little potential of contamination to the channel bottom sediments from this source, or from any other hydrocarbon source such as oil wells, crude oil pipelines, or accidental hydrocarbon product spills. It would be more likely to find contamination around active wells or pipelines that are located on emergent land. During the 1995 field investigation, there were no visual signs of contamination noted along emergent shorelines or around wells, buried pipelines or product storage tanks located on emergent lands within the Laguna Madre (EH&A, 1995).

Potential contamination impacting the sediments of the channel area or emergent lands from the release of drill mud during well drilling activities is also of little likelihood. The use and discharge of drilling muds are restricted and contaminant or toxicity potential resulting from normal usage would be considered minimal. Even in the event of an accidental spill of large proportions, the hazardous nature of drilling mud is considered insignificant. In summary, the review of available data and the visual reconnaissance indicated minimal risk of the presence, or potential presence, of HTRW sites within the Laguna Madre (EH&A, 1995). Overall, the potential for shipping related spills is more likely.

3.9 AIR QUALITY

The coastal climate of Nueces County may be described as subhumid to semiarid. Major climatic influences are temperature, precipitation, evaporation, wind, and tropical storms/hurricanes. This area is subject to extreme precipitation variability. For the Corpus Christi, Nueces County area, rainfall averages about 29 inches per year, with the greatest concentration falling in the spring and fall months. The peak rainfall in the fall coincides with the tropical storm/hurricane season. Rainfall totals decrease toward the southern coastline and inland to the west. The temperatures in the Corpus Christi area are fairly high with an average in the lower 70s, punctuated with occasional killing freezes. The persistent wind is from the southeast from March to September and the northeast from October to February. The hurricane season spans June through November with the greatest number occurring in the area in August and September. Wind velocities may be at least 74 mph with wind gusts exceeding sustained wind speeds by up to 50 percent during tropical storms (Dunn and Miller, 1964).

The Laguna Madre area is located along the Texas Gulf Coast. The climate in this area is predominantly influenced by its proximity to the Gulf of Mexico, and thus has a warm, subtropical climate characterized by dry winters and hot, humid summers. Temperatures range from an average winter minimum in the 40s and 50s (degrees Fahrenheit) to summer highs in the 80s and 90s (Brown et al., 1977; Soil Conservation Service [SCS], 1977). In general, summer temperatures are highest and winter temperatures lowest as the distance from the Gulf of Mexico increases. The prevailing winds are generally southeasterly to south-southeasterly throughout the year except in winter, when they may become northeasterly. There is the potential for ozone and photochemical smog formation usually during the months from April to October due to intense solar radiation, low wind speeds, and elevated temperatures. Wind patterns may result in the transport of ozone or precursors of ozone, resulting in increased ozone concentrations at locations downwind of the source of these air contaminants. Rainfall may help cleanse the atmosphere of some pollutants, especially dust emissions. Rainfall is generally concentrated during the late summer and fall months. The average annual rainfall ranges from 34.5 inches in the north end of Kleberg County (Brown et al., 1977) to 26 inches in Cameron County (SCS, 1977).

PBS&J and Ward (1999) reduced and analyzed a 1994–1998 wind direction and velocity data set in the Laguna Madre at two locations: near the Arroyo Colorado in the LLM and near South Bird Island in the ULM. The conclusions from this data set are, logically, similar to the information provided above:

1. The annual wind roses are dominated by prevailing southeast winds from the Gulf of Mexico. There is year-to-year variation in the annual winds. Monthly wind roses display a shift from predominantly southeasterly wind regimes in summer to bimodal in winter (i.e., alternating southeasterly and northerly winds resulting from frontal passages).

2. Power spectra of wind are characterized by a prominent spike at exactly one cycle per day (cpd); i.e., period 24 hours. This is the signal from the seabreeze. The seabreeze spike is present throughout the year, minimal during the winter months,

and maximal in the period June – September. The greatest seabreeze energy is in the east-west component, transverse to the coastline.

3. Several lower frequency signals, particularly around 3- and 6-day periodicities appear in the wind spectra for the fall through spring period, being maximal in winter. These are the result of frontal passages during the winter and equinoctial seasons. Most of the energy of the frontal-passage periodicities is in the north-south component.

The Clean Air Act, which was last amended in 1990, requires the EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards:

1. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly.

2. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

The EPA Office of Air Quality Planning and Standards has set NAAQSs for six principal pollutants that are called "criteria" pollutants. They are carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), lead (Pb), particulate matter (PM), and sulfur dioxide (SO_2). Particulate matter has been further divided into particulate matter with particle diameters of 10 micrometers or less (PM_{10}) and particulate matter with particle diameters of 2.5 micrometers or less ($PM_{2.5}$). Air quality is generally considered acceptable if pollutant levels are less than or equal to established standards on a continuous basis.

In 1997, the EPA announced a new national ambient air quality standard for ground-level ozone, the primary constituent of smog. The new standard was challenged in the Federal courts. The courts upheld the standard, but the EPA is required to revise its implementation plan. In the interim, EPA has reinstated the old 1-hour standard but has not yet made public its revised implementation plan. The new 8-hour standard of 0.08 parts per million (ppm) (85 parts per billion [ppb] to exceed the standard) is determined by the fourth highest 8-hour daily maximum at any single monitor in an area, averaged over a 3-year period. The previous 1-hour standard of 0.12 ppm (125 ppb to exceed) was reinstated and currently applies to all areas. The NAAQS are summarized in Table 3-5.

The Clean Air Act also requires the EPA to assign a designation to each area of the U.S. regarding compliance with the NAAQS. EPA categorizes the level of compliance or noncompliance as follows:

- Attainment – area currently meets the NAAQS
- Maintenance – area currently meets the NAAQS, but has previously been out of compliance
- Nonattainment – area currently does not meet the NAAQS

TABLE 3-5

NATIONAL AMBIENT AIR QUALITY STANDARDS AND TNRCC PROPERTY-LINE NET GROUND LEVEL CONCENTRATION STANDARDS

Air Constituent	Averaging Time	NAAQS Primary	NAAQS Secondary
Sulfur Dioxide (SO_2)	30-min.	---	---
	3-hr.	---	0.50 ppm
	24-hr.	0.14 ppm	
	Annual Arithmetic Mean	0.03 ppm	
Particulate Matter (PM)	1-hr.	---	---
	3-hr.	---	---
Inhalable Particulate Matter (PM_{10})	24-hr.	150 $\mu g/m^3$	150 $\mu g/m^3$
	Annual Arithmetic Mean	50 $\mu g/m^3$	50 $\mu g/m^3$
Fine Particulate Matter ($PM_{2.5}$)	24-hr.	65 $\mu g/m^3$	65 $\mu g/m^3$
	Annual Arithmetic Mean	15 $\mu g/m^3$	15 $\mu g/m^3$
Nitrogen Dioxide (NO_2)	Annual Arithmetic Mean	0.053 ppm	0.053 ppm
Carbon Monoxide (CO)	1-hr.	35 ppm	---
	8-hr.	9 ppm	---
Lead (Elemental) (Pb)	3-mo. (Calendar Quarter)	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$
Ozone (O_3)	1-hr.	0.12 ppm	0.12 ppm
	8-hr.	0.08 ppm	0.08 ppm

The TCEQ is responsible for monitoring air and water quality within the State and for reporting that information to the EPA and the public. The staff examines and interprets the causes, nature, and behavior of air pollution in Texas. The TCEQ operates several monitors located in the study area. The monitors are used to measure meteorological parameters such as air temperature, wind velocity, and other meteorological parameters. The ozone monitors operate continuously 24 hours a day, 7 days a week, and are checked by technicians who perform equipment maintenance and conduct quality assurance checks.

Monitored values for the criteria pollutants in Nueces County are shown in Table 3-6. No data are available for CO, NO_2 or Pb. The monitoring data show that since 1996, monitored values have been below the NAAQS for all except the 8-hour ozone standard. When measured by the 8-hour standard, Corpus Christi had an exceedance of the standard in 1999. Although Nueces County is considered to be "near nonattainment" for ozone under Federal air quality standards, it is currently in attainment with the NAAQS for all other air contaminants for which a standard has been set.

Monitored data for Cameron County for the years 1996 through 2001 are also shown on Table 3-6. These data indicate that the area is in attainment with the NAAQS for all criteria pollutants. Although no current data are available for the remaining counties, Kleberg, Kenedy, and Willacy counties are also considered to be in attainment with the Federal air quality standards.

3.10 NOISE

Noise is defined as unwanted sound that disrupts or interferes with normal activities or that diminishes the quality of the environment. Noise is usually caused by human activity and is added to the natural, or ambient, acoustic setting of an area. Exposure to high levels of noise over an extended period can cause health hazards such as hearing loss, however, the most common human response to environmental noise is annoyance. Several factors affect response to noise levels including background level, noise character, level fluctuation, time of year, time of day, history of exposure, and community attitudes. Typically, people are more tolerant of a given noise level if the background level is closer to the level of the noise source. People are more tolerant of noises during daytime than at night. Residents are more tolerant of a facility or activity if it is considered to benefit the economic or social well being of the community.

Sound is sensed by the human ear when a source emits oscillations through an elastic medium, such as air. Sound is characterized by two magnitudes: frequency and amplitude. The frequency of a sound corresponds to the human sensation of pitch and is measured in Hertz (Hz). The amplitude of a sound corresponds to the human sensation of loudness. Human reaction to loudness, or sound pressure, is measured in terms of sound pressure levels, and expressed in terms of decibels (dB). Decibels are measured on a logarithmic scale in order to compress the wide range between the human threshold of hearing and the threshold of pain. A sound level of 0 dB is approximately the threshold of human hearing and is barely audible under extremely quiet listening conditions. Normal speech has a sound level of approximately 60 dB. Sound levels of approximately 120 dB begin to be felt inside the ear as discomfort and increases to pain at higher levels.

TABLE 3-6

MONITORED VALUES COMPARED TO NAAQS
NUECES AND CAMERON COUNTIES

County	Year	2nd 24-hr Value for PM_{10} $\mu g/m^3$)	Annual Mean Value for PM_{10} ($\mu g/m^3$)	2nd Max 1-hr Value for O_3 (ppm)	4th Max 8-hr Value for O_3 (ppm)	2nd Max 24-hr Value for SO_2 (ppm)	Annual Mean Value for SO_2 (ppm)	2nd Max 1-hr Value for CO (ppm)	2nd Max 8-hr Value for CO (ppm)	Annual Mean Value for NO_2 (ppm)	Quarterly Mean Value for Pb ($\mu g/m^3$)
Nueces	1996	45	25.1	0.103	no data	0.015	0.002	no data	no data	no data	no data
	1997	74	30.5	0.094	0.077	0.020	0.003	no data	no data	no data	no data
	1998	67	34.9	0.102	0.082	0.029	0.003	no data	no data	no data	no data
	1999	88	35.2	0.103	0.085	0.019	0.002	no data	no data	no data	no data
	2000	71	35.7	0.099	0.083	0.017	0.003	no data	no data	no data	no data
	2001	48	27.6	0.090	0.077	0.017	0.002	no data	no data	no data	no data
	2002	no data	no data	no data	0.080	no data	no data	no data	no data	no data	no data
Cameron	1996	40	20.7	0.077	no data	0.004	0.001	4.8	2.2	no data	0.02
	1997	103	29.6	0.080	0.065	0.001	0.001	6.0	3.2	no data	0.01
	1998	110	29.6	0.081	0.071	0.005	0.001	8.1	3.2	no data	0.01
	1999	87	40.7	0.075	0.066	0.004	0.001	4.4	2.6	no data	0.01
	2000	58	25.4	0.080	0.064	0.002	0.001	3.3	1.6	no data	0.01
	2001	89	35.5	0.070	0.063	no data	no data	2.2	1.2	no data	0.01
	2002	no data	no data	no data	0.060	no data	no data	no data	no data	no data	no data
NAAQS		150	50	0.12	0.08	0.14	0.03	35	9	0.053	1.5

Ref: EPA AirData, Monitor Summary Report, 2002.
No data are available for Kleberg, Kenedy, or Willacy Counties.

Sounds of the same pressure but different frequencies are not perceived by the human ear as equally loud. The human ear is less sensitive to low frequencies and high frequencies, and is most sensitive to the mid-range frequencies that correspond with human speech. Therefore, in order to measure sound in a manner similar to human perception, an adjustment known as "A" weighting is used. All regulatory agencies require that measurements be taken using the A-weighted sound level (dBA). Although A-weighted sound measurements indicate the level of environmental noise at any given time, community noise levels vary constantly. Typical noise environments consist of numerous noise sources that vary and fluctuate over time. Because of the varying noise levels within a community, it is necessary to use a descriptor called the equivalent sound level (L_{eq}). L_{eq} is the average sound level, in decibels, for any time period under consideration.

The EPA has developed the day-night level (L_{dn}) which is defined as the A-weighted average sound level for a 24-hour period. It is calculated by adding a 10 dBA penalty to nighttime (10:00 P.M. to 7:00 A.M.) sound levels to account for increased sensitivity to noise during the evening hours. The EPA generally recognizes residential areas to have an average L_{dn} of 55 dBA. The U.S. Department of Housing and Urban Development (HUD) sets a site acceptability L_{dn} standard of below 65dBA.

The immediate activities that affect the existing noise environment of communities within the project area include waterborne transportation (i.e., barges, commercial fishing vessels, sport and recreation boats, etc.) and dredging. The noise levels within the project area would increase in proximity to urban communities due to vehicular traffic, commercial airlines, and major construction activities.

3.11 CULTURAL RESOURCES

The project area encompasses the coastal land and the portions of Padre Island surrounding the Laguna Madre and falls entirely within the Southern Coastal Corridor (SCC) Archeological Region of the Central and Southern Planning Region of Texas (Mercado-Allinger and Ricklis, 1996). This archeological region encompasses the Coastal Bend from the Colorado River in Matagorda County south to the Rio Grande (Bailey, 1987; Ricklis, 1990). The current project area is in Nueces, Kleberg, Kenedy, Willacy, and Cameron counties, which are five of the ten counties in this region that front on the Gulf of Mexico. The remaining five counties that make up the SCC Archeological Region are inland.

The SCC Archeological Region contains five subareas which each possess unique geographic and cultural features. The current study area is included in the Baffin/Oso, Sandsheet, and Deltaic Plain subareas. In the Baffin/Oso subarea, which encompasses Nueces and Kleberg counties, the primary resource zones are the coastal estuaries and terrestrial flood plains with adjacent prairies. Hypersaline tidal flats in which vegetation is generally limited to stable dunes and occasional blowouts dominate the Sandsheet subarea, which covers Kenedy and northern Willacy counties. The Deltaic Plain is the southernmost subarea in the project area and consists of southern Willacy and Cameron counties. The Deltaic Plain is characterized by more vegetation than the Sandsheet subarea, and fish resources are similar to those in the Baffin/Oso subarea. Due to hypersalinity, mollusk production in the Laguna Madre is low (Mercado-Allinger et al., 1996).

Although this region contains an archeological sequence that includes Paleoindian, Archaic, Late Prehistoric, and Historic periods, evidence of Paleoindian sites is sparse throughout the region.

3.11.1 Cultural History Overview

Archeological evidence supports the continued presence of indigenous groups in the SCC Archeological Region from at least 10,000 B.C. through the time of European contact and colonization (Mercado-Allinger and Ricklis, 1996). The generally accepted cultural history of the area is divided into four periods: the Paleoindian, Archaic, Late Prehistoric, and Historic. Each of these periods is briefly summarized below.

The Paleoindian period in the SCC Archeological Region is the earliest recognized cultural period dating from at least 10,000 B.C. to circa 6000 B.C. Little is known about this initial adaptation of the region, but researchers have suggested that this period was marked by a very low population density, small band sizes, and extremely large territorial ranges (Black, 1989). Material indications of the Paleoindian period include projectile point types such as *Clovis*, *Folsom*, *Scottsbluff*, *Meserve*, and *Angostura*. Many of the Paleoindian diagnostic materials are surface finds although some have been from subsurface contexts. Sites with possible Paleoindian components include the Buckner Ranch (41BE2), the Berger Bluff site (41GD30), the Petronila Creek site (41NU246), and the La Paloma site (41K17) in Kenedy County (Mercado-Allinger and Ricklis, 1996). The River Spur site (41VT112) has also yielded Paleoindian artifacts from the surface and subsurface deposits (Cloud et al., 1994).

In Nueces County the presence of early materials along Oso and Petronila creeks indicates assemblages dating to Paleoindian times in this region (Shafer and Bond, 1983). In the early 1900s in Cameron County, A.E. Anderson reportedly recovered an isolated find consisting of one Clovis point base from near the LANWR. W.A. Price reported mammoth bones eroding in the same vicinity in later years (Suhm et al., 1954). However, on Padre Island the time prior to about 2,000 years ago is very poorly understood. Remains dating to this period are usually mixed with later occupations, although occasional, widely scattered isolated Paleoindian artifacts such as the *Meserve* point from 41CF104 and an *Angostura*-like point from 41KL3 have been encountered on Padre Island. However, given that both of these points pre-date the formation of the island by 4000 to 5000 years (Nordby and Murphy, 1984), it is possible that later island occupants may have brought them there. On the barrier islands proper, the earliest occupation may have been during the final phase of the Early Archaic.

The Archaic period (approximately 6000 B.C. to A.D. 1200) is identified during the early and middle Holocene by intensive human utilization of a wide variety of ecological niches including the coastal zone. The Archaic period is divided into the Early (6000 B.C.–2500 B.C.), Middle (2500 B.C.–1000 B.C.), and Late (1000 B.C.–1000 A.D.) subperiods. As with the Paleoindian culture, evidence of Early and Middle Archaic cultures is equally scarce. The Early Archaic is the least understood but represents a period of transition beyond the Paleoindian period. Some characteristics of the Paleoindian period are still present, such as careful chipping of stone tools and occupation of older sites, yet distinctive artifact styles are found. Large triangular points, corner notched points, stemmed points (*Gower*) and large-barbed points (*Bell*) begin to appear. Population density remained low during this time and large territorial ranges were still utilized (Black, 1989). Sites dating to this subperiod occur in the SCC Archeological Region. Sites with identified Early Archaic deposits include the McKinzie Site (Ricklis, 1986, 1988), the Means Site (41NU124), and the Shumla Site (41VT17) (Fox and Hester, 1976; Ricklis, 1993). It is during the final phase of this subperiod that the earliest occupation of Padre Island may have occurred. This roughly coincides with the formation of Padre Island.

During the Middle Archaic subperiod exploitation of marine resources appears to have accelerated. This is often evidenced by the thicker shell strata evident in shell middens as well as the more abundant fish remains. The presence of central Texas related groups on Padre Island during the Middle Archaic and later periods is more conclusively indicated. Clear Fork Phase *Nolan* and *Travis* type dart points, dated to the beginning of the Middle Archaic period (Prewitt, 1981) occur at three sites: 41KL5, 41KL8, and 41KL9, (Campbell, 1964). Single specimens of later Middle Archaic *Lange* points (Prewitt, 1981) were collected from site 41KL3 (Campbell, 1964).

Inland Late Archaic sites are abundant and varied. Point types known to occur include *Castroville* and *Frio*-like (41KL11), *Ensor* (41KL3), and *Darl* (41KL3 and 41KL11) (Campbell, 1964). Point types also include *Ellis* (Campbell, 1964), east Texas dart points that occur as minor types in the central Texas Archaic. South Texas point types are also relatively abundant during the Late Archaic period; these are discussed in the following section. It should be emphasized that throughout the major portion of the Archaic period, the use of Padre Island and other coastal areas was apparently infrequent and sporadic in nature. Primarily stream-oriented inland groups experimented with the exploitation of the coastal environment during this period.

For the Texas coast, the Aransas phase is generally accepted as the representative Late Archaic phase (Campbell, 1956). Beginning around A.D. 1 and terminating approximately A.D. 1200, groups adapted to the coastal environment exploited shellfish, fish, birds, and, to a certain extent, small mammals. Settlement during this phase is characterized by summer occupations in the interior portions of Padre Island, resulting in open lithic scatters. Shell midden sites located along the mainland coast as well as more inland areas were occupied at other times. The shell middens from this time period yield a greater range and quantity of artifacts than do the shell middens dating to the Early Archaic. The abundance and variety of sites from this time period suggests more frequent and/or intensive occupations than previously occupied sites and, perhaps, a higher regional population density (Ricklis, 1995). The predominant dart point occurring south of Corpus Christi Bay is stemless, whereas stemmed dart points are found north of Corpus Christi Bay (Corbin, 1974). Campbell (1964) confined the extent of the Aransas phase to the area around Aransas and Corpus Christi Bay; however, Corbin (1974) extended this range to include materials from the Colorado River to Baffin Bay.

Numerous cemeteries have been identified in the SCC Archeological Region dating to the Late Archaic and Late Archaic/Late Prehistoric associations. Many of the previously recorded sites (e.g., 41NU5, 41KL2, 41KL10, and 41KL11) in the northern portion of the project area were recorded as primarily Late Archaic/Late Prehistoric sites.

The Late Prehistoric Period is represented by the Rockport phase over the northern portion of the project area. With the advent of the bow and arrow and ceramic vessels, the Rockport phase replaces the Aransas phase. The later phase is characterized by the exploitation of larger game and an intensified exploitation of fish (Campbell, 1964). Settlement and subsistence patterns during the Rockport phase involved, to a significant degree, shifting seasonal emphases, with occupation of shoreline fishing camps during the fall through winter-early spring, and later spring through summer residences at hunting camps commonly located along the upland margins of stream valleys (Ricklis, 1995). Both shell middens and lithic sites of this phase tend to be stratified, indicating seasonally inhabited sites. This is probably because food resources along the coast and on the barrier islands tend to be seasonally available (Thomas and Weed, 1980a, 1980b).

Weinstein and Kelley (2002) citing Smith (1986) and Aten (1983), respectively, noted two other late prehistoric settlement models for the Texas coast. In Smith's model, permanent base camps located on the bay shores were supported by smaller extraction sites. Aten's model was developed for the "upper coast" historic Akokisa. The Akokisa congregated in villages within the interior during the winter and dispersed during the spring and summer to the coast. Weinstein and Kelley note that this model is opposite to that developed by Ricklis (1995). Weinstein and Kelley (2002) noted that these differences may be due to environmental factors.

Artifacts representative of the Rockport phase include *Perdiz* projectile points as well as *Fresno*, *Young*, *Cliffton*, *Scallorn*, and *Starr* types and *Rockport* ceramic wares (Campbell, 1956). In terms of resource exploitation and cultural assemblages, the pattern for this phase tentatively established a link between the Rockport phase sites and the Karankawas, a historically known coastal group of Coahuiltecan-speaking indigenous people (Thomas and Weed, 1980a, 1980b). The Rockport phase dates from about A.D. 100 until the extinction of the Karankawas in the mid-nineteenth century. Most of the prehistoric sites thoroughly investigated in the area are interpreted as reflecting littoral adaptations with a secondary dependence on inland prairie resources (Prewitt, 1984).

Historically, the Karankawa are reported to have camped at shell midden sites located near sources of freshwater whenever possible. Artifacts associated with Rockport phase sites include shell containers, jewelry, shell working-tools, asphaltum, burned clay nodules, sandstone shaft straighteners, and decorated ceramics including polychrome (Calhoun, 1964), asphaltum-painted black on gray (Fitzpatrick et al., 1964) and scallop-shell scored (Calhoun, 1964). Rockport phase sites recorded within the project area include 41KL7 and 41NU9.

The Brownsville Complex is one of two closely related cultural complexes MacNeish (1947) defined for the Lower Rio Grande delta. Common to both complexes are shell disks; pierced shell disk beads; plugs made from a columella, which are round in cross section; rectangular conch shell pendants; mollusk shell scrapers; and *Starr*, *Fresno*, and *Matamoros* projectile points. Intrusive pottery of Huastecan origin from southern Tamaulipas appears in occupation sites and in burials (Anderson, 1932; Mason, 1935; MacNeish, 1947). Brownsville Complex sites occur almost exclusively in Cameron County, Texas, and have cultural materials similar to those from Rockport phase sites north of Baffin Bay. Rockport phase sites and Brownsville Complex sites exhibit triangular arrowpoints, scrapers, conch shell gouges, and some shell ornaments. *Rockport* pottery has been found on some Brownsville Complex sites as well. Pierced whole conch shells; small snail shell beads; conical pumice pipes; bivalve beads; Marginella beads; conch shell fishhooks; *Cameron* projectile points; shell plugs with rectangular cross sections; columella gouges; and chipped, pin-like drills are diagnostic of this complex (Hester, 1995).

Late Prehistoric cemeteries and burials are relatively common along the Texas coast and are often found in clay dunes (Headrick, 1993). One coastal cemetery is documented for the Oso Creek/Oso Bay area in Nueces County. According to Hester (1980), the Texas coast encompasses the largest number of prehistoric cemeteries in the region. One of these cemetery sites, 41NU2 (Calle del Oso), is one of the largest known cemeteries. At one time it may have contained as many as 600 burials. Unfortunately, this site has been largely destroyed by development and adequate studies were never conducted at the site. It is believed that site 41NU2 may have also been in use during the Late Archaic period. Another cemetery located in Nueces County is the Berryman Site (41NU173) (Hall, 1987). Late prehistoric sites within the project area that are known to have included human burials are 41NU287 and 41CF74. The eroded remains from site 41CF74 could possibly be from a Brownsville Complex burial given that they were stained with red ochre. Brownsville Complex burials have been found at the Floyd A. Morris site (41CF2) in Cameron County (Collins et al., 1969). Brownsville Complex burials are characteristically flexed, bundled, or cremated, and are often accompanied by large amounts of grave goods and sometimes covered in red ochre (Hester, 1995).

The post contact historic period for the Texas coast and south Texas effectively begins with the explorations of the Gulf of Mexico by Spanish explorers seeking to locate new land and economic resources for the Spanish royal crown in Madrid. Following Alonzo Pineda's initial mapping of the Gulf of Mexico and Corpus Christi Bay in 1519, Cabeza de Vaca traversed the area in the 1520s (Tyler, 1996).

3.11.2 Historic Coastal Groups

Two historic Indian groups inhabited the Texas coastal area: the Coahuiltecan and the Karankawas. These nomadic hunters and gatherers were decimated by European diseases and by encroachment of the Spaniards from the south and the Apaches and Comanches from the north, as well as the Anglo-Americans from the east. By 1850 neither the Coahuiltecans nor the Karankawas occupied the coastal area (Campbell, 1956).

3.11.2.1 Coahuiltecans

The Coahuiltecans settled primarily on the mainland and only after contact with the Spaniards did they venture out onto Padre Island (Thomas and Weed, 1980a, 1980b). Some of the Coahuiltecan bands were the Orejon, west of Corpus Christi Bay; the Malaquite, along the coast from Corpus Christi Bay to Baffin Bay; and the Borrado, in the area from Baffin Bay to the Rio Grande (Scurlock et al., 1974). Each band occupied a territory that included both inland and coastal areas at either end of their yearly round. Population was estimated to be about 15,000 individuals with about 220 bands identified in 1690; however, by 1870 only remnants of the population remained (Thomas and Weed, 1980a, 1980b). The influence of the Coahuiltecans on Padre Island was primarily from their trade with the

Karankawa. The Coahuiltecan worked extensively with basketry, which they traded with the Karankawa, and to a lesser degree with ceramics.

Recent research has indicated that the Coahuiltecans probably never existed as a single tribe (Gardner, 2001; Hester, 1999). Rather groups with similar language were identified by the Spanish as Coahuilteco presumably because the native homeland of many of the groups was Coahuila, Mexico. There is no extant Coahuiltecan tribe today; however, there is a group based in the San Antonio are that calls itself the Coahuiltecan Nation (Gardner, 2001). This group is not recognized by the Federal government or the State of Texas as a Native American tribe.

3.11.2.2 Karankawas

Five major Karankawa groups were historically documented near the project area and included the Capoques and Hans to the north; the Kohanis around the mouth of the Colorado; the Karenkake, Clamcoets, and Carancaquacas on Matagorda Bay and Matagorda Island; and the Kopanos, along Copano Bay and St. Joseph Island (Scurlock et al., 1974). According to early European accounts, the Karankawa subsisted primarily on oysters, clams, scallops, other mollusks, turtles, various fish species, porpoises, and several marine plant species (Thomas and Weed, 1980a, 1980b). Other ethnographic and archeological evidence supports the contention that historic Karankawas resided during the fall and winter in large shoreline camps of 400–500 people, during the spring and summer they camped along stream courses in bands averaging about 55 individuals (Ricklis, 1992). Karankawa sites were generally located in sheltered bays or on the leeward side of stabilized dunes on the Laguna Madre side of Padre Island (Thomas and Weed, 1980a, 1980b).

Like the Coahuiltecans, cultural material of the Karankawa was sparse. Huts were constructed of willow branches covered with brush, with hearths in the center of each hut. They did, however, use several varieties of ceramics for cooking and eating. These were decorated and sometimes coated with asphaltum. The ceramics were globular in shape, reminiscent of Rockport phase types (Thomas and Weed, 1980a, 1980b).

3.11.3 <u>History of Padre Island</u>

Padre Island is a sand barrier island along the coast of south Texas. Extending for about 130 miles, Padre Island has the longest sand beach in the U.S. (Tyler, 1996). The first documentation of Padre Island was in 1519 when Alonso Alvarez de Pineda explored, mapped, and described the Texas coast (Castaneda, 1936). On April 9, 1554, three ships (the San Esteban, the Espiritu Santo, and the Santa Maria de Yciar) originally from Sanlucar, Spain, were caught in a storm and wrecked on Padre Island near Mansfield Pass (Arnold and Weddle, 1978). A fourth ship, the San Andres, survived the storm and sailed back to Havana with news of the disaster that befell the other ships. Three hundred survivors were marooned on the Gulf side of Padre Island. Attempting to walk south along the beach toward Mexico, the survivors fell under several attacks by native peoples (likely the Coahiltecans or the Karankawa), and most died. The only persons rescued on the island were Francisco Vasquez and Fray

Marcos de Mena. Spanish salvage operations recovered slightly less than half of the total million ducats lost (Arnold and Weddle, 1978). These ships are now a part of the Mansfield Cut Archaeological District.

For approximately the next 250 years, excursions onto the island by Spanish or, later, Mexican officials were limited either to rescue expeditions or to responses to military conditions (Thomas and Weed, 1980a, 1980b). No settlement of the area was attempted until the early 1800s (Sheire, 1971). The first recorded permanent habitation on Padre Island occurred in 1805 when Padre Nicolas Balli and his nephew established a ranch, Rancho Santa Cruz de Buena Vista, about 24 miles from the southern end of the island and introduced horses and cattle to the island (Lea, 1957; Sheire, 1971). Initially, Padre Balli was an absentee landowner who hired hands to run his ranch. He did not actually occupy the island himself until about 1811, during a period of political disorder in the Mexican government. His family maintained the cattle industry through the 1830s, selling parts of the island along the way. The northern half was purchased and ranched by Santiago Morales and was later sold to Jose Maria Tovar in 1845. The southern half was acquired by Nicolas Grisante (Sheire, 1971).

The city of Corpus Christi had its beginnings with a trading post established near the northern end of the island in 1839. During the Mexican-American War, General Zachary Taylor had an outpost and supply depot at Port Isabel near the southern end of the island. Captain Ben McCulloch and his Texas Rangers, en route to assist Taylor's forces, first brought the Texas flag to Padre Island in 1845. Shortly thereafter, lieutenant George Meade conducted a 10-day mapping survey of Padre Island and the waters of the Laguna Madre. In 1848 Padre Island became a part of the U.S. under the Treaty of Guadalupe Hidalgo. During the Civil War, at least one small engagement took place on the island during the Union's blockade of Corpus Christi Bay. During their occupation, Union troops frequently appropriated provisions from island ranches.

In 1854 steamboat captain and pioneer cattle rancher, Richard King, purchased 12,000 acres on Padre Island from a niece of Padre Balli. Little is known of the post-Civil War period history of the island. Aside from King's ranching operations, a small community of fishermen and a beef pickling plant were established on the northern end of the island. The pickling plant discontinued operations in 1874.

In the 1870s, Richard King and his associate Mifflen Kenedy began fencing their mainland rangelands. As other landowners followed suit, the open range of south Texas gradually disappeared, and many largely landless cattle owners were driven out of business. One of these cattle owners, Patrick Dunn, began leasing land in 1879 on Padre Island which was all but deserted at the time. He began ranching on the island with 400 head of cattle, and subsequently began buying the island a piece at a time. By the mid-1920s, Dunn had purchased most of the island and had grazing rights to the few tracts of land he did not own. In 1926, he sold the entirety of his land holding to Colonel Sam Robertson for $125,000. In 1927, Robertson ventured to invest in the tourism trade by constructing a resort hotel and a wooden causeway from Flour Bluff to North Padre Island. However, both the causeway and the hotel were destroyed by a storm in 1933 (Scurlock et al., 1974). Though Dunn had sold his land, he retained grazing rights, and his family continued to graze cattle on Padre Island until 1971 when the last of the livestock were removed. In 1962 the U.S. Congress created a bill authorizing the establishment of the PINS (Sheire, 1971).

The earliest attempt to create a resort community on Padre Island began in 1907 when the Tarpon Beach resort was planned for the southern end of the island (Scurlock et al., 1974).

3.11.3.1 King Ranch

The King Ranch is an 825,000-acre cattle ranch stretching across Nueces, Kleberg, Kenedy, and Willacy Counties. Kenedy and King began acquiring land in Kenedy County in 1847. King and several partners purchased the rest of the land over time starting in 1853. The large ranch is well known for its production of Santa Gertrudis cattle. Oil drilling and refining added to the financial growth of the ranch.

3.11.3.2 Nueces County

Nueces County, located 145 miles southeast of San Antonio, covers approximately 847 square miles of the Coastal prairies region. Nueces County was formed and organized from San Patricio County in 1846 with Corpus Christi as the county seat (Tyler, 1996). The population of the county remained low during the early years. The isolation and the continued threat of Indian attacks kept many would-be settlers away. In 1854, a yellow fever epidemic decimated the small population.

In the years prior to the Civil War, the main economic force in the county was ranching. During the Civil War, the area became an important center for Confederate commerce. According to Tyler (1996), at least 45 small vessels carried trade between Corpus Christi and Indianola. Small boats sailing inside the barrier island transported goods from the Brazos River to the Rio Grande, while inland cotton was moved along the Cotton Road through Banquete to Matamoros and onto the mills in England. In an effort to halt the trade, Union forces seized control of Mustang Island in the fall of 1863. Twice, Federal gunboats bombarded Corpus Christi disrupting water transportation, while overland trade continued without interruption until the end of the war.

After the Civil War and into the early 1900s, agricultural development and industrialization characterized Nueces County's economy. Other important industries in the twentieth century have been oil and natural gas (Tyler, 1996). In 1922, natural gas was discovered in Nueces County and within a few years, several major oilfields were developed.

The Port of Corpus Christi was opened in 1926. The channel from the Gulf of Mexico to the turning basin, which also connects to the GIWW, connects the port with cities to the north, east, and south along the Gulf of Mexico as well as foreign markets (Tyler, 1996). Since the port and channel were first opened, channel depths have been increased to accommodate larger ships.

3.11.3.3 Kleberg County

Kleberg County covers approximately 853 square miles of the Rio Grande Plains region of South Texas. Originally part of a Spanish land grant, the portion of Kleberg County in the Santa Gertrudis grant was purchased in 1853 by Richard King. A tract of the land, through which the St. Louis, Brownsville, and Mexico Railway ran, was sold in 1903, and the town of Kingsville was laid out. In response to pressure from increasing population in the Kingsville area, Kleberg County was organized as a separate county from part of Nueces County in 1913 with Kingsville as the county seat (Tyler, 1996). Oil production and agriculture played an important role in the county's economy for most of the twentieth century.

3.11.3.4 Kenedy County

Kenedy County covers approximately 1,389 square miles of the Rio Grande Plains region of South Texas (Tyler, 1996). Kenedy County had its earliest roots in Spanish and Mexican ranch activity. Many of the original ranches were abandoned around the time of the Texas Revolution due to hostility from the indigenous people and political turmoil. American settlement increased after the Mexican War, and the future Kenedy County was the scene of much of the turmoil surrounding the "skinning wars" that pitted Mexican and Anglo ranchers against one another. During the mid to late 1800's, King and Kenedy fenced in much of the ranchland as King Ranch. Kenedy County was among the last of the Texas counties to be formed. It was formed from the northern ranching portion of Willacy County, with Sarita as its county seat, in 1921, when Willacy, Cameron, and Hidalgo counties were redrawn. Although oil production has played a role in the economic profile of Kenedy County since 1947, most of the county is still owned by only a few ranchers primarily specializing in livestock (Tyler, 1996).

3.11.3.5 Willacy County

Willacy County, located 30 miles north of Mexico, covers approximately 589 square miles of the Rio Grande Valley in south Texas (Tyler, 1996). Most of the land that would become Willacy County was parts of only three original Spanish and Mexican land grants in the late eighteenth century. Most of the original ranch land was abandoned by 1811 due to hostile Indians, though. Willacy County was formed in 1911 with Sarita as the county seat. Its boundary was redrawn in 1921 to include the small southernmost portion of the original county, and Raymondville was named the new county seat (Tyler, 1996). The Port Mansfield Channel is a pass that was first cut through Padre Island in northeastern Willacy County in 1957. The channel was completed in 1962 (see Neville et al., 1990 for a complete history of the Mansfield Cut).

3.11.3.6 Cameron County

Cameron County, located north of Mexico and roughly 90 miles south of Corpus Christi, covers approximately 905 square miles of the Rio Grande Plains region of south Texas (Tyler, 1996). The land that is now Cameron County was first colonized by the Spanish in the late eighteenth century, after which it was claimed as part of the Mexican state of Tamaulipas. Following the 1836 signing of the Treaty of Velasco, even though it was still claimed by Mexico, the Texans claimed the land as part of San Patricio

County. Zachary Taylor established Fort Brown across from Matamoros and several battles in the ensuing Mexican War were fought within Cameron County. During the Mexican War, Fort Polk (41CF10) in Port Isabel was used by Taylor as a garrison site. Cameron County was officially decreed in 1848 and officially became a part of the U.S. later that year with the signing of the Treaty of Guadalupe Hidalgo. Although Santa Rita was originally declared the county seat, Brownsville was set as the county seat late in 1848. The county, at that time, was 3,308 square miles and encompassed much of present-day Hidalgo, Willacy, Kenedy, and Brooks counties (Tyler, 1996).

In the early years, the county rapidly became an important trade center (Tyler, 1996). The Port Isabel Lighthouse was built on the site of the former Fort Polk in 1852. The river transport company set up by King, Kenedy, and Charles Stillman dominated river transportation. Land disputes marked much of the period before the Civil War, and, after the Civil War, much of the land ended up in the control of only a few large land owners such as King and Kenedy. Farming became an important source of economic support for the county in the late nineteenth century and continues as such, today. The St. Louis, Brownsville and Mexico Railway, built through the county in 1904, contributed greatly to a land boom in the early 1900s bringing many prospective land-buyers every day from as far away as the Midwest (Tyler, 1996).

3.11.3.7 Previous Investigations

The earliest and most extensive work in the southern portion of the study area is that of A.E. Anderson. From 1908 to 1940, Anderson, a civil engineer by training, collected and kept accurate records of data from almost 400 sites in Cameron County and adjacent parts of Tamaulipas, Mexico. In 1932, he published a brief description of his artifacts from the Brownsville area (Anderson, 1932). Artifacts from his collection are generally typical of cultural material found on the Lower Rio Grande Delta, and his collection reflects the predominance of a shellworking industry that has frequently been called the outstanding characteristic of the area by later investigators. Many professional archeologists have relied heavily on the Anderson collection as a supplement to their own survey data to make interregional comparisons and to establish chronological schemes (Sayles, 1935; Jackson, 1940; Campbell, 1947; MacNeish, 1947; Prewitt, 1974). Many of the sites originally recorded by Anderson have been relocated and rerecorded by later archeologists. For others, little information other than location is currently known. The latter sites have not been assigned trinomial numbers. Four such sites lie within the project area. These sites have not been assigned trinomials by the Texas Archeological Research Laboratory (TARL).

In the Baffin Bay area, archeological investigations were first initiated during the 1920s. C.T. Reed excavated portions of a cemetery near Loyola Beach (Reed, 1937). Archeological investigations in the vicinity of the Port Mansfield Entrance Channel have centered around the three wrecks of the 1554 Spanish fleet. Investigations related to these wrecks have included Arnold and Weddle (1978), Arnold (1976), Gearhart et al. (1990), and Gearhart and Schmidt (1999).

Since the acquisition of portions of Padre Island by the NPS, two major archeological investigations have been conducted within PINS, as well as a number of more limited surveys related to proposed oil exploration and extraction activities. The first professional investigations on Padre Island were conducted by T.N. Campbell in 1963. Campbell relied on a number of avocationals during his reconnaissance survey of the then-proposed PINS (Campbell, 1964). His survey areas were located between Corpus Christi Bay and a point about 15 miles north of Mansfield Pass. A total of 15 prehistoric and proto-historic sites were recorded, 12 of which were within the then-proposed boundary of PINS. Three distinct clusters of sites were documented but were confined to the northern end of the island. The significance of this distribution, however, is uncertain because of erratic ground surface visibility and other problems in site identification.

Limited archeological investigations completed in the SCC Archeological Region include two cultural resource surveys located near the mouth of Baffin Bay. Both were conducted by New World Research (NWR) in 1980 (Thomas and Weed, 1980a, 1980b). Combined, both surveys totaled approximately 5.5 miles of proposed pipeline easement. The length was examined at 66-foot intervals. The ground surface was generally visible, but grass was removed in an attempt to improve the visibility in heavily vegetated areas (Thomas and Weed, 1980a). In both surveys, systematic and intuitively placed auger holes were also excavated in an attempt to locate buried cultural materials. No evidence of either prehistoric or historic occupations was observed. The following year, NWR completed two surveys of proposed seismic lines opposite Port Mansfield (NWR, 1981a, 1981b). No sites were recorded during either of these surveys.

The Center for Archeological Research (CAR) conducted surveys at three proposed well pad drilling sites (Gibson and Hester, 1982; Valdez, 1982; Warren, 1985). Two of the drilling sites are within the PINS near Yarborough Pass (Valdez, 1982; Warren, 1985), and the third is located in the vicinity of South Bird Island (Gibson and Hester, 1982). Investigations at all three of the drilling sites consisted of a surface examination only; no subsurface excavations were conducted. No cultural resources were observed at any of the well pad locations. Also within PINS, two alternative well pad locations were surveyed in 1984 by Prewitt & Associates, Inc. (Fields, 1984). The surface examination encountered areas of both poor and good visibility but found no evidence of either prehistoric or historic occupations. Two shallow trowel tests were dug in each pad location in order to document subsurface sediments.

Several major archeological investigations have been conducted in the project vicinity. In 1980, the Texas Department of Water Resources conducted a survey of the proposed Allison Wastewater Treatment Plant. Two large prehistoric sites, 41NU185 and 41NU186, were identified. Site 41NU185, a multi-component prehistoric midden, was subsequently tested by Texas A&M University (Carlson et al., 1982). In 1984, the USACE conducted a survey of two large proposed dredged disposal areas (Good, 1984). The survey resulted in the identification of one archeological site, 41NU211, a large prehistoric occupation site.

TPWD has also completed an archeological survey and history of Mustang Island in eastern Nueces County (Howard et al., 1997). The survey recorded two previously unknown sites, 41NU284 and 41NU285, and relocated one previously recorded site 41NU224. All three sites contain prehistoric components and two of the sites, 41NU224 and 41NU284, also contain late nineteenth century and early twentieth century components.

Cultural resource management surveys and testing programs have proliferated in the Baffin/Oso subarea since the 1970s (Mercado-Allinger and Ricklis, 1996). This work has provided models of Late Prehistoric settlement and subsistence patterns, as well as native responses to Spanish colonization (Patterson and Ford, 1974; Carlson, 1983; Warren, 1987). Additionally, these investigations have also contributed to the enhancement of the Archaic chronology of the region (Ricklis and Cox, 1991; Ricklis, 1993, 1995).

3.11.3.8 Shipwrecks

The Texas Historical Commission's (THC) shipwreck files and NOAA's Automated Wreck and Obstruction Information System (AWOIS) were examined to determine whether any known shipwrecks are located within the project area. The accuracy of these positions is considered tentative. Positions for historic shipwrecks are generally located from contemporary records or maps, or plotted based on oral histories. Historic documents generally refer to shipwreck locations in terms of distance and direction from contemporary landmarks. The positions of those landmarks often cannot be determined from current information. Shipwrecks listed on the THC shipwreck files are often listed by the corner coordinates and numbers of GLO mineral lease blocks. Lease blocks are typically 1 square mile. A shipwreck location stated as a lease block number, or a block's corner coordinates, is only accurate to within 1 mile.

The AWOIS database positions are also inconsistent as shipwrecks could be listed within a range of accuracy. It is important, therefore, to consider those shipwrecks that plot adjacent to, as well as those directly within, the current study area. Further research is needed to determine which, if any, AWOIS charted shipwrecks are potentially historically significant.

Numerous shipwrecks have been recorded within the Laguna Madre, particularly within the area of Port Isabel. However, a review of the locations of these shipwrecks shows that none coincide with any of the existing or proposed PAs (Hoyt, 2003).

3.11.3.9 Records and Literature Review

A literature and records review was conducted to identify recorded cultural resource sites and to determine the location and type of sites previously identified in the project area. Files at TARL were reviewed for locations and information on previously recorded sites in or near the study area. Files at the Texas Historical Commission (THC) were reviewed for previous archeological investigations in the study area. Listings in the National Register of Historic Places (NRHP) were reviewed for sites listed in, or determined eligible for, inclusion on the NRHP. The list of State Archeological Landmarks (SAL) prepared by the Department of Antiquities Protection at the THC was consulted for sites determined significant by the State. The Historical Marker Program of the THC was also consulted.

Based on the site location maps at TARL, the literature and records review revealed 56 previously recorded sites and one isolated find within the Laguna Madre study area (Table 3-7). The THC records identified two (41CF10 and 41KL64) of the 56 sites as having been listed in the NRHP. Site 41CF10 is the Civil War era Port Isabel Lighthouse and Zachary Taylor's Garrison at Fort Polk. Site

TABLE 3-7

ARCHEOLOGICAL SITES WITHIN THE LAGUNA MADRE STUDY AREA

Site Number	Quadrangle Map	Type of Investigations	Eligibility Status	Reference
41CF10	Port Isabel	survey, mitigation	NRHP listed, SAL designated	
41CF104	Port Isabel NW	survey		TARL site form
41CF113	Port Isabel SW	survey		TARL site form
41CF144	La Coma	survey		TARL site form
41CF31	La Coma	Cameron County Survey		TARL site form
41CF32	La Coma	Cameron County Survey		TARL site form
41CF34	La Coma	Cameron County Survey		TARL site form
41CF35	La Coma	Cameron County Survey		TARL site form
41CF43	La Coma	Cameron County Survey		TARL site form
41CF44	La Coma	Cameron County Survey		TARL site form
41CF49	La Coma	Cameron County Survey		TARL site form
41CF73	La Coma	Cameron County Survey		TARL site form
41KL1	South Bird Island SE			TARL map
41KL11	South Bird Island			TARL map
41KL12	Pita Island			TARL map
41KL57	Point of Rock			TARL map
41KL58	Point of Rock			TARL map
41KL59	Crane Islands SW	THC survey 008968		TARL map
41KL6	Pita Island	THC survey 008968		TARL map
41KL60	Crane Islands SW	THC survey 008968		TARL map
41KL61	Pita Island	THC survey 008968		TARL map
41KL64	South Bird Island	survey	NRHP listed, SAL designated (under Novillo Line Camp)	
41KL65	South Bird Island SE	New World Research Inc., survey		TARL site form
41KL7	South Bird Island			TARL map
41KL8	Pita Island			TARL map
41KL99	South Bird Island SE	Not Available		TARL map
41KN10	So. of Potrero Lopeno NE	THC survey	NRHP listed	TAC Underwater Archaeological Research Section [WML], 1972
41KN11	So. of Potrero Lopeno NE	THC survey008604		TARL site form
41KN15	Potrero Lopeno SE	THC survey 008608		TARL site form
41KN16	So. of Potrero Lopeno NE	survey		TARL site form

TABLE 3-7 (Cont'd)

ARCHEOLOGICAL SITES WITHIN THE LAGUNA MADRE STUDY AREA

Site Number	Quadrangle Map	Type of Investigations	Eligibility Status	Reference
41KN2	So. of Potrero Lopeno NE	Kenedy-Kleberg survey		TARL site form
41KN22	Potrero Lopeno SE	THC survey		TARL site form
41KN23	South Bird Island SE	EH&A survey		EH&A Doc. No. 19846
41NU12	Pita Island			TARL site form
41NU219	Crane Islands NW	Packery Point Survey		Warren, J.E. Report 114
41NU224	Crane Islands NW	survey		TARL site form
41NU233	Oso Creek NE	survey		TARL site form
41NU273	Oso Creek NE	survey		TARL site form
41NU284	Crane Islands NW	survey		TARL site form
41NU285	Crane Islands NW	survey		TPWD 1995 Annual Report
41NU287	Pita Island	survey		TARL site form
41NU288	Crane Islands NW			TARL site form
41NU41	Oso Creek NE			TARL site form
41NU44	Oso Creek NE			TARL site form
41NU45	Oso Creek NE	survey		TPWD 1995 Annual Report
41NU5	Crane Islands NW	survey		TARL site form
41NU6	Crane Islands SW	survey		TARL site form
41NU68	Oso Creek NE	survey		TARL site form
41NU69	Oso Creek NE			TARL site form
41NU7	Crane Islands NW			TARL site form
41NU70	Oso Creek NE			TARL site form
41WY142	So. of Potrero Lopeno SE	survey		TARL site form
41WY3	So. of Potrero Lopeno SE	Survey 1972		TPWD 1995 Annual Report
41WY4	North of Port Isabel NW	Survey 1975		TARL site form
41WY47	Hawk Island	Survey 1980		TARL site form
41WY48	Hawk Island	Survey 1980		TARL site form

41KL64 consists of the remaining portions of the Dunn Ranch Novillo line camp. Three SAL designated sites (41CF10, 41KN10, and 41KL64) were also identified during the THC file review. Site 41KN14 consists of the remnants of the Dunn Ranch line camp. Records for 12 historical markers were found for the study area in Cameron County, four in Nueces County, and one in Willacy County. Of these markers, the old Port Isabel Lighthouse marker and the Brazos Santiago marker on the southern end of Padre Island are 1936 Civil War Centennial Markers. The Alta Vista Apartments marker in Port Isabel marks a Registered Texas Historical Landmark.

3.12 SOCIOECONOMIC RESOURCES

Of all Texas bays, the Laguna Madre was probably the least influenced in the early 1970s by humankind, although there was considerable evidence of human activity (Warshaw, 1975). Thirty years later, the Laguna Madre is still the least impacted of Texas bays, although the evidence of expanding human activity is still present. This section presents a summary of economic and demographic characteristics for Cameron, Kenedy, Kleberg, Nueces, and Willacy counties (hereafter "the study area counties") and the cities of Brownsville, San Benito, Port Isabel, South Padre Island, and Corpus Christi (hereafter "the study area cities"). Socioeconomic information for these study area counties and cities is compared with information for the State of Texas. Population and employment growth, commercial and recreational fishing, recreation and tourism, waterborne transportation, dredging, and land use are the key factors discussed.

3.12.1 Population

Of the five study area counties, only Cameron County exceeded the State annual average population increase of 1.9 percent between 1980 and 2000 (Table 3-8). Population growth in Cameron County has been very strong over the 20-year period, increasing by 28.9 percent since 1990 to reach an estimated 335,227 by the 2000 Census. While Nueces County follows close behind in total population (313,645 in 2000), growth rates dropped slightly during the 1990s and the annual average increase since 1980 is less than 1.0 percent. The major population center in Nueces County includes the City of Corpus Christi and surrounding communities. Flour Bluff and North Padre Island within the Corpus Christi city limits are the developed areas closest to the GIWW within the study area. Although Willacy County has experienced increased growth in the 1990s to reach 20,082 by the 2000 Census, the annual average population increase, between 1980 and 2000, in Willacy County is still only 0.6 percent. Kleberg County recorded a net population decline between 1980 and 1990, but the 2000 Census places the county at 31,549 representing a 4.2 percent increase over 1990 figures. The population in Kenedy County is by far the smallest for all study area counties. Although the county has experienced a steady decline in population since 1980, total population has only dropped by 129 people to 414 people as reported by the 2000 Census. The headquarters of the King Ranch, which covers much of Kleberg and Kenedy counties, is situated in Kingsville (USBOC, 1980, 1990, and 2000).

TABLE 3-8

POPULATION TRENDS
1980 - 2000

Area	Population 1980	Population 1990	Population 2000	Percent Change 1980-90	Percent Change 1990-2000	Percent Change Average Annual 1980-2000
Cameron County	209,727	260,120	335,227	24.0%	28.9%	2.4%
Brownsville	84,997	98,962	139,722	16.4%	41.2%	2.5%
San Benito	17,988	20,125	23,444	11.9%	16.5%	1.3%
Port Isabel	3,769	4,467	4,865	18.5%	8.9%	1.3%
South Padre Island	791	1,677	2,422	112.0%	44.4%	5.8%
Nueces County	268,215	291,145	313,645	8.5%	7.7%	0.8%
Corpus Christi	231,999	257,453	277,454	11.0%	7.8%	0.9%
Willacy County	17,705	17,705	20,082	0.0%	13.4%	0.6%
Kleberg County	33,358	30,274	31,549	-9.2%	4.2%	-0.3%
Kenedy County	543	460	414	-15.3%	-10.0%	-1.3%
Texas	14,229,191	16,986,510	20,851,820	19.4%	22.8%	1.9%

Source: USBOC, 1980, 1990, and 2000.

3.12.1.1 Projected Growth

As shown in Table 3-9, population forecasts provided by the TWDB indicate that Cameron and Nueces counties will have the strongest population growth rates through 2050, with Cameron County growth surpassing State growth rates each decade through 2030. The population in Cameron County exceeded 335,000 by 2000 and is expected to grow to 650,000 by 2050, representing an annual average growth rate of 1.4 percent. The Nueces County population exceeded 313,000 in 2000, and is expected to grow to greater than 565,000 by 2050, representing an annual average growth rate of 1.3 percent. Willacy County is expected to experience moderate growth through 2020, with declining growth rates each decade through 2050, and population growth rate is expected to be far below that of the State by 2050, at 2.8 percent (as compared with 8.8 percent for the state). Similarly, Kleberg County is expected to experience moderate growth through 2020, with the rate of population growth declining each subsequent decade to 2050. The population growth rate in this county is expected to be lower than that of the State by 2050, at 5.2 percent. Although population growth in Kenedy County should remain positive through 2010, it is expected to be negative between 2010 and 2050, and population growth is expected to drop to −11.9 percent by 2050 (TWDB, 2002; USBOC, 2000).

Generally speaking, the populations of the study area counties have a greater proportion of people of Hispanic origin than the overall State of Texas and a smaller proportion of people in the other race categories (Table 3-10). The study area county with the highest proportion of Hispanic persons is Cameron County (84.3%); which is almost three times that of the State (32.0%). Even with the smallest proportion of Hispanic persons, Nueces County has almost twice the proportion of Hispanic persons (55.8%) as the State. The study area county with the greatest percentage of White persons is Nueces County (37.7%) and the county with the smallest percentage of White persons is Willacy County (11.7%). These proportions are substantially below that of the State, which has 71.0 percent White persons. The study area county with the highest proportion of African American persons is Nueces (4.1%) and the county with the lowest proportion is Kenedy County (0.0%). Texas had a much greater proportion of African American persons in 2000 (11.5%). The study area county with the greatest proportion of persons of other races was Kleberg County (2.6%) and Willacy County had the least (0.6%). The proportion of persons of other races in the study area counties is much lower than that of the State (17.6%) (USBOC, 2000).

The trends in ethnicity demonstrated within the study area counties, are generally reflected within the study area cities, with some caveats (Table 3-10). The population living in the city of South Padre Island is much different in ethnicity from other study area cities. It has a much higher proportion of White persons and a much smaller proportion of Hispanic persons. The study area city with the highest proportion of Hispanic persons is Brownsville (91.3%); which is almost three times that of the State. The study area city with the smallest proportion of Hispanic persons, South Padre Island (22.8%), is lower than that of the State. The study area city with the greatest percentage of White persons is South Padre Island (75.0%) and the study area city with the smallest percentage of White persons is Brownsville (7.7%). The study area city with the highest proportion of African American persons is Corpus Christi (4.5%), and the city with the lowest proportion is San Benito (0.1%). The study area city with the greatest

TABLE 3-9

DETAILED 1990 POPULATION CHARACTERISTICS BY CITY, COUNTY AND STATE

Area	Year						Percent Change				
	2000	2010	2020	2030	2040	2050	2000-10	2010-20	2020-30	2030-40	2040-50
Cameron County	335,227	405,463	476,992	554,513	614,396	652,931	21.0%	17.6%	16.3%	10.8%	6.3%
Brownsville	139,722	172,894	201,684	239,281	253,728	269,049	23.7%	16.7%	18.6%	6.0%	6.0%
San Benito	23,444	28,737	32,721	38,447	40,570	42,811	22.6%	13.9%	17.5%	5.5%	5.5%
Port Isabel	4,865	6,447	7,340	8,625	9,100	9,602	32.5%	13.9%	17.5%	5.5%	5.5%
South Padre Island	2,422	2,887	3,396	3,945	4,372	4,844	19.2%	17.6%	16.2%	10.8%	10.8%
Nueces County	313,645	374,552	422,288	470,779	520,861	565,502	19.4%	12.7%	11.5%	10.6%	8.6%
Corpus Christi	277,454	335,580	379,799	424,861	471,428	523,099	20.9%	13.2%	11.9%	11.0%	11.0%
Willacy County	20,082	23,722	25,857	27,284	28,280	29,077	18.1%	9.0%	5.5%	3.7%	2.8%
Kleberg County	31,549	42,058	46,262	49,750	52,585	55,313	33.3%	10.0%	7.5%	5.7%	5.2%
Kenedy County	414	520	504	457	405	357	25.6%	-3.1%	-9.3%	-11.4%	-11.9%
State of Texas	20,851,820	24,537,141	28,792,303	32,413,817	36,413,817	39,617,389	17.7%	17.3%	12.6%	12.3%	8.8%

Sources: Texas Water Development Board, 2002; USBOC, 2000.

TABLE 3-10

2000 ETHNICITY CHARACTERISTICS BY CITY, COUNTY AND STATE

Place/Detailed Study Area Census Tracts	Population	# White	% White	# African American	% African American	# Hispanic Origin	% Hispanic	# Other	% Other
Cameron County	335,227	48,679	14.5%	909	0.3%	282,736	84.3%	3,237	1.0%
Brownsville	139,722	10,826	7.7%	276	0.2%	127,535	91.3%	1,085	0.8%
San Benito	23,444	2,919	12.5%	27	0.1%	20,380	86.9%	118	0.5%
Port Isabel	4,865	1,190	24.5%	16	0.3%	3,619	74.4%	40	0.8%
South Padre Island	2,422	1,817	75.0%	14	0.6%	553	22.8%	38	1.6%
Nueces County	313,645	118,178	37.7%	12,718	4.1%	174,951	55.8%	7,798	2.5%
Corpus Christi	277,454	106,901	38.5%	12,404	4.5%	150,737	54.3%	7,412	2.7%
Willacy County	20,082	2,350	11.7%	401	2.0%	17,209	85.7%	122	0.6%
Kleberg County	31,549	8,997	28.5%	1,091	3.5%	20,635	65.4%	826	2.6%
Kenedy County	414	84	20.3%	0	0.0%	327	79.0%	3	0.7%
State of Texas	20,851,820	14,804,792	71.0%	2,397,959	11.5%	6,672,582	32.0%	3,669,920	17.6%

Source: USBOC, 2000.

proportion of persons of other races was Corpus Christi (2.7%) and San Benito had the least (0.5%). The proportion of persons of other races in the study area cities is much lower than that of the state of Texas (USBOC, 2000).

3.12.1.2 Community Characteristics

This section provides analysis of various population demographics. Provided below is USBOC information collected for the following categories: educational attainment, household tenure, length of residency, and income.

In terms of educational attainment (Table 3-11), the county with the greatest proportion of persons 18 years and older with a bachelor's, graduate, or other professional degree is Kleberg County (18.9%) and the county with the lowest proportion is Kenedy County (7.8%). In the State, the proportion of such persons is 18.1 percent. The study area city with the highest level of educational attainment is South Padre Island where 31.9 percent of persons 18 years or older have earned a bachelor's, graduate, or professional degree. The study area city with the lowest proportion of such persons, is Port Isabel (7.3%) (USBOC, 1990).

"Household Tenure" is a category that distinguishes between owner-occupied housing units and renter-occupied housing units (Table 3-12). The 2000 census shows that owner-occupied housing units are more abundant than renter-occupied housing units in all of the study area counties, except for Kenedy County. The study area county with the greatest percentage of owner-occupied housing units is Willacy County (77.3%), and Kenedy County had the lowest percentage (34.8%). For comparison, the State of Texas had a proportion of owner-occupied housing units of 63.8% for that year. Among the study area cities, San Benito had the highest proportion of owner-occupied housing units (69.4%) and Corpus Christi had the lowest (59.6%) (USBOC, 2000).

The "Length of Residency" category shows the number and percentage of residents that moved into their homes between different year categories (Table 3-13). A majority of the study area residents moved into their homes between 1995 and 2000. However, in Kenedy County, relatively high percentages of residents moved into their homes between 1999 and 2000 (26.6%) (USBOC, 2000).

An examination of per capita incomes within study area counties shows that the per capita incomes in these counties are all lower than that of the State ($19,617) in 2000 (Table 3-14). The county with the highest per capita income was Nueces County ($17,036), and the county with the lowest per capita income was Willacy County ($9,421). All of the study area cities except for South Padre Island had lower per capita incomes than the State. The study area city with the highest per capita income in 2000 was South Padre Island ($31,708) and the city with the lowest per capita income was Brownsville ($9,762) (USBOC, 2000).

In 2000 all of the study area counties had lower median household incomes than that of the state ($39,927) in 2000 (Table 3-14). The study area county with the highest median household income was Nueces County ($35,959) and the county with the lowest median household income was Willacy County ($22,114). All of the study area cities except for South Padre Island had lower median

TABLE 3-11

EDUCATIONAL ATTAINMENT BY CITY, COUNTY AND STATE

	Percent of Persons 18 Years and Older		
Study Area Census Tracts	High School Graduate	Bachelors Degree	Graduate or Professional Degree
Cameron County	19.7%	8.0%	3.9%
Brownsville	10.4%	5.2%	2.7%
San Benito	19.2%	5.9%	3.3%
Port Isabel	25.5%	6.6%	0.7%
South Padre Island	20.0%	20.5%	11.4%
Nueces County	24.4%	11.1%	5.8%
Corpus Christi	24.4%	11.7%	6.1%
Willacy County	21.8%	6.0%	2.7%
Kleberg County	20.9%	10.8%	8.1%
Kenedy County	25.3%	6.0%	1.8%
State of Texas	26.0%	12.6%	5.5%

Source: USBOC, 2000.

TABLE 3-12

TENURE BY CITY, COUNTY AND STATE

Place/Detailed Study Area Census Tracts	# Occupied Household Units	Owner Occupied Units	% Owner Occupied Units	Renter Occupied Units	% Renter Occupied Units
Cameron County	97,267	65,875	67.7%	31,392	32.3%
Brownsville	38,174	23,361	61.2%	14,813	38.8%
San Benito	7,065	4,905	69.4%	2,160	30.6%
Port Isabel	1,649	984	59.7%	665	40.3%
South Padre Island	1,211	769	63.5%	442	36.5%
Nueces County	110,365	67,679	61.3%	42,686	38.7%
Corpus Christi	98,791	58,912	59.6%	39,879	40.4%
Willacy County	5,584	4,316	77.3%	1,268	22.7%
Kleberg County	10,896	6,384	58.6%	4,512	41.4%
Kenedy County	138	48	34.8%	90	65.2%
State of Texas	7,393,354	4,716,959	63.8%	2,676,395	36.2%

Source: USBOC 2000.

TABLE 3-13

LENGTH OF RESIDENCY BY CITY, COUNTY AND STATE

Place/Detailed Study Area Census Tracts	# Occupied Housing Units	Year Householder Moved into Residence											
		1999 to March 2000	%	1995 to 1998	%	1990 to 1994	%	1980 to 1989	%	1970 to 1979	%	1969 or Earlier	%
Cameron County	97,267	19,792	20.3%	27,422	28.2%	15,451	15.9%	16,626	17.1%	9,036	9.3%	8,940	9.2%
Brownsville	38,224	8,352	21.9%	10,527	27.5%	6,071	15.9%	6,353	16.6%	3,699	9.7%	3,222	8.4%
San Benito	7,187	1,294	18.0%	1,889	26.3%	990	13.8%	1,123	15.6%	715	9.9%	1,176	16.4%
Port Isabel	1,651	350	21.2%	461	27.9%	260	15.7%	262	15.9%	137	8.3%	181	11.0%
South Padre Island	1,214	371	30.6%	478	39.4%	189	15.6%	146	12.0%	30	2.5%	0	0.0%
Nueces County	110,365	26,392	23.9%	29,944	27.1%	16,437	14.9%	15,310	13.9%	10,952	9.9%	11,330	10.3%
Corpus Christi	98,808	24,753	25.1%	27,001	27.3%	14,488	14.7%	13,275	13.4%	9,601	9.7%	9,690	9.8%
Willacy County	5,584	724	13.0%	1,088	19.5%	840	15.0%	944	16.9%	878	15.7%	1,110	19.9%
Kleberg County	10,896	2,896	26.6%	2,730	25.1%	1,380	12.7%	1,452	13.3%	1,226	11.3%	1,212	11.1%
Kenedy County	138	9	6.5%	37	26.8%	24	17.4%	13	9.4%	19	13.8%	36	26.1%
State of Texas	7,393,354	1,842,731	24.9%	2,233,669	30.2%	1,126,526	15.2%	1,030,476	13.9%	630,749	8.5%	529,203	7.2%

Source: USBOC, 2000

TABLE 3-14

INCOME BY CITY, COUNTY AND STATE

Area	Number of Persons	Per Capita Income	Median Household Income	# Below Poverty	% Below Poverty
Cameron County	335,227	$10,960.00	$26,155	109,288	32.6%
Brownsville	140,075	$9,762.00	$24,468	49,701	35.5%
San Benito	23,615	$10,317.00	$24,027	7,668	32.5%
Port Isabel	4,868	$11,239.00	$25,323	1,318	27.1%
South Padre Island	2,455	$31,708.00	$45,417	294	12.0%
Nueces County	313,645	$17,036.00	$35,959	56,097	17.9%
Corpus Christi	277,569	$17,419.00	$36,414	47,842	17.2%
Willacy County	20,082	$9,421.00	$22,114	6,300	31.4%
Kleberg County	31,549	$13,542.00	$29,313	8,028	25.4%
Kenedy County	414	$17,959.00	$25,000	61	14.7%
State of Texas	20,851,820	$19,617.00	$39,927	3,117,609	15.0%

Source: USBOC, 2000.

household incomes than the State. The study area city with the highest median household income in 2000 was South Padre Island ($45,417) and the city with the lowest median household income was Port Isabel ($24,027) (USBOC, 2000).

In 2000, most all of the study area counties had greater proportions of persons living below the poverty line than the State of Texas (15.0%) (Table 3-14). The study area county with the highest proportion of persons living below the poverty line was Cameron County (32.6%), and the county with the lowest proportion was Kenedy County (14.7%). All of the study area cities, except for South Padre Island, had greater proportions of persons living below the poverty line than the State. The study area city with the highest proportion of persons living below the poverty line was Brownsville (35.5%), and the city with the lowest proportion of persons living below the poverty line was South Padre Island (12.0%) (USBOC, 2000).

3.12.2 Employment and Economics

Within the five-county study area, the majority of the economic activity is concentrated in the northern (Nueces County) and southern extremes (Cameron County). Employment in these two counties represented approximately 95% of all employment within the five counties in 2000 (Texas Workforce Commission (TWC), 2002a) (Table 3-15).

According to the TWC, most of the jobs in Cameron County in 2000 were in the services (28.1%) and trade sectors (23.8%). Government (Federal, State and local) (23.6%) and manufacturing (11.4%) are other important industry sectors within this county. The industry sector with the greatest percent increase in jobs between 1998 and 2000 was the construction industry, which grew by 21.3%. The total labor force in Cameron County was 110,819 in 2000, representing a 10.2% increase over the 1998 employment level. This rate of job growth was higher than that of the State during the same years (7.2%). Unemployment rates in Cameron County were 12.7% in 1990 and 9.2% in 2001 (Table 3-16), higher than that of the state (6.3% in 1990, 5.1% for 2001) (TWC, 2002a).

In Nueces County in 2000, the greatest number of employees was within the services (31.1%) and trade sectors (23.8%). The government sector (18.4%) also represents an important industry sector in this county in terms of the number of employees. The industry sector with the greatest percent increase in jobs, between 1998 and 2000 was the agriculture, forestry, and fisheries industry, which grew by 11.4 percent. The total labor force of this county was 142,846 in 2000, representing a 0.5 percent increase over the 1998 employment level. This rate of employment growth was substantially lower than the State's. Unemployment rates in Nueces County were 6.7 percent in 1990 and 5.7 percent in 2001, only slightly higher than that of the State for both years (TWC, 2002a).

In Willacy County in 2000, the greatest number of employees was in the government (39.0%) and trade sectors (19.3%). The services sector (17.6%) and the agriculture, forestry, and fisheries sector (11.9%) also represent important industry sectors within this county in terms of numbers of employees. The industry sector with the greatest percent increase in jobs between 1998 and 2000 was the transportation and public utilities industry, which grew by 11.1 percent. The total labor force of this

TABLE 3-15

MAJOR EMPLOYMENT SECTORS BY COUNTY AND STATE

Employment Sector	4th Quarter Employment 1998	4th Quarter Employment 2000	Percent Total Employment 1998	Percent Total Employment 2000	% Change 1998-2000
Cameron County, Texas					
Agriculture Services, Forestry, Fisheries	1425	1,425	1.42%	1.29%	0.00%
Mining	NA	21	NA	0.02%	NA
Construction	3,408	4,135	3.39%	3.73%	21.33%
Manufacturing	12,376	12,600	12.31%	11.37%	1.81%
Transportation and Public Utilities	4,612	5,279	4.59%	4.76%	14.46%
Trade	24,218	26,397	24.09%	23.82%	9.00%
Finance, Insurance, and Real Estate	3,565	3,729	3.55%	3.36%	4.60%
Services	27,207	31,138	27.06%	28.10%	14.45%
Federal/State/Local Government	23,731	26,095	23.60%	23.55%	9.96%
Total Employment	100,542	110,819			10.22%
Nueces County, Texas					
Agriculture Services, Forestry, Fisheries	981	1,093	0.69%	0.77%	11.42%
Mining	2,049	1,775	1.44%	1.24%	-13.37%
Construction	11,136	12,139	7.84%	8.50%	9.01%
Manufacturing	10,323	9,998	7.27%	7.00%	-3.15%
Transportation and Public Utilities	6,646	7,241	4.68%	5.07%	8.95%
Trade	33,927	34,044	23.88%	23.83%	0.34%
Finance, Insurance, and Real Estate	5,759	5,824	4.05%	4.08%	1.13%
Services	44,593	44,402	31.39%	31.08%	-0.43%
Federal/State/Local Government	26,660	26,330	18.76%	18.43%	-0.43%
Total Employment	142,074	142,846			0.54%
Willacy County, Texas					
Agriculture Services, Forestry, Fisheries	454	409	12.28%	11.92%	-9.91%
Mining	82	34	2.22%	0.99%	-58.54%
Construction	38	33	1.03%	0.96%	-13.16%
Manufacturing	NA	81	NA	2.36%	NA
Transportation and Public Utilities	171	190	4.63%	5.54%	11.11%
Trade	660	661	17.86%	19.27%	0.15%
Finance, Insurance, and Real Estate	92	83	2.49%	2.42%	-9.78%
Services	779	602	21.08%	17.55%	-22.72%
Federal/State/Local Government	1,420	1,338	38.42%	39.00%	-22.72%
Total Employment	3,696	3,431			-7.17%
Kleberg County, Texas					
Agriculture Services, Forestry, Fisheries	487	464	4.41%	4.36%	-4.72%
Mining	426	294	3.86%	2.76%	-30.99%
Construction	317	365	2.87%	3.43%	15.14%
Manufacturing	259	264	2.35%	2.48%	1.93%
Transportation and Public Utilities	176	180	1.59%	1.69%	2.27%
Trade	2,381	2,317	21.56%	21.75%	-2.69%
Finance, Insurance, and Real Estate	328	329	2.97%	3.09%	0.30%
Services	2,088	1,804	18.91%	16.93%	-13.60%
Federal/State/Local Government	4,581	4,637	41.48%	43.52%	-13.60%
Total Employment	11,043	10,654			-3.52%

TABLE 3-15 (Cont'd)

Employment Sector	4th Quarter Employment 1998	4th Quarter Employment 2000	Percent Total Employment 1998	Percent Total Employment 2000	% Change 1998-2000
Kenedy County, Texas					
Agriculture Services, Forestry, Fisheries	113	108	35.42%	34.62%	-4.42%
Mining	NA	NA	NA	NA	NA
Construction	NA	NA	NA	NA	NA
Manufacturing	0	0	0.00%	0.00%	NA
Transportation and Public Utilities	0	0	0.00%	0.00%	NA
Trade	0	0	0.00%	0.00%	NA
Finance, Insurance, and Real Estate	0	0	0.00%	0.00%	NA
Services	117	120	36.68%	38.46%	2.56%
Federal/State/Local Government	89	84	27.90%	26.92%	-5.62%
Total Employment	319	312			-2.19%
State of Texas					
Agriculture Services, Forestry, Fisheries	112,122	118,946	1.28%	1.26%	6.09%
Mining	161,825	154,553	1.84%	1.64%	-4.49%
Construction	510,140	558,400	5.81%	5.93%	9.46%
Manufacturing	1,112,130	1,087,717	12.66%	11.56%	-2.20%
Transportation and Public Utilities	540,570	592,207	6.16%	6.29%	9.55%
Trade (Retail)	2,158,875	2,297,058	24.58%	24.41%	6.40%
Finance, Insurance, and Real Estate	492,374	512,010	5.61%	5.44%	3.99%
Services	2,359,868	2,509,642	26.87%	26.67%	6.35%
State/Local/Federal Government	1,333,442	1,570,906	15.18%	16.69%	6.35%
Total Employment	8,781,346	9,411,578			7.18%

Sources: Texas Workforce Commission (TWC), 2002a.

NA - not available.

TABLE 3-16

UNEMPLOYMENT RATES BY COUNTY AND STATE

	Unemployment Rates	
	1990	2001
Cameron County	12.7%	9.2%
Kenedy County	3.9%	1.8%
Kleburg County	7.1%	4.8%
Nueces County	6.7%	5.7%
Willacy County	16.7%	16.4%
Texas	6.3%	5.1%

Source: Texas Workforce Commission (TWC), 2002b.

county was 3,431 in 2000, representing a 7.2 percent decrease from the 1998 employment level. This employment decrease is in sharp contrast to the employment growth in the State during this period. Unemployment rates in Willacy County were 16.7 percent in 1990 and 16.4 percent in 2001, which are both substantially higher than the State's for both years (TWC, 2002a).

In Kleberg County in 2000, the greatest number of employees was in the government (43.5%) and trade sectors (21.8%). The services sector (18.9%) also represents an important industry sector within this county. The industry sector with the greatest percent increase in jobs between 1998 and 2000 was the construction industry, which grew by 15.1 percent. The total labor force of this county was 10,654 in 2000, representing a 3.5 percent decrease from the 1998 employment level. Unemployment rates in this county were 7.1 percent in 1990 and 4.8 percent in 2001, which were relatively close to that of the State during those years (TWC, 2002a).

In Kenedy County in 2000, the greatest number of employees was found in the services (38.5%) and agriculture, forestry, and fisheries sectors (34.6%). The only other industry sector that is represented within this county is the government sector (26.9%). The industry sector with the greatest percent increase in jobs between 1998 and 2000 was the services sector, which grew by 2.6 percent. The total labor force of this county was only 312 in 2000, representing a 2.2 percent decrease from the 1998 employment level. Unemployment rates in Kenedy County were 3.9 percent in 1990 and 1.8 percent in 2001, which were lower than that of the State for both years (TWC, 2002a).

Employment estimates, at the county level, do not accurately portray employment within the much more narrowly defined project area. An economic study prepared by Texas A&M – Department of Agricultural Economics provided details on specific employment industries within the project study area (Tanyeri-Abur et al., 1998). This 1998 study determined that employment within the project area consisted primarily of extensive ranching and crop production, tourism, transportation, and construction. The study stated that in 1995 the number of employees in the project area was approximately 181,000.

Within the study area counties, the greatest level of economic activity occurs in Nueces and Cameron counties. Agricultural, apparel manufacturing industries, and health services are important industries in Cameron County, while petroleum manufacturing is important in Nueces County. Within the study area counties, along the GIWW, land is primarily devoted to extensive ranching, crop production, or is vacant of economic activities. Also important within the Laguna Madre, are water-related recreation activities, including the Corpus Christi bay area in the north and South Padre Island resort area in the south. Baffin Bay and other areas of the Laguna Madre, such as The Hole and Emmord's Hole, are popular sport fishing destinations (Tanyeri-Abur et al., 1998).

Several expansive ranches abut the Laguna Madre, including Kenedy Ranch, King Ranch, and Yturrias Ranch. The largest of these, the King Ranch, occupies approximately 825,000 acres within Kleberg and Kenedy counties.

3.12.2.1 Commercial and Recreational Fishing

Commercial fishing continues to be an important industry along the south Texas coast and constitutes a moderate component of navigational traffic in the Laguna Madre. Approximately 98 percent of the commercial fish and shellfish landed in the Gulf of Mexico, including the south Texas region are dependent on estuaries for reproduction, nursery areas, food production, or migration (TCMP, 1996). Texas generally ranks among the top states nationally in terms of dollar value of commercial fish and shellfish landed.

Commercial fishing within the ULM and LLM is a significant contributor to the economy in the project area. Table 3-17 compares the commercial landings of the ULM with all Texas bay systems in 1999. The total wholesale value for all finfish and shellfish landings in the ULM system in 1999 was $1,516,045, or 4.7 percent of the wholesale value of all such landings for all Texas bay systems in that same year ($32.6 million). For this bay system, black drum is the most noteworthy of the finfish or shellfish species in terms of its commercial value. In 1999, the wholesale value of black drum was $1,501,830 in 1999, or 99.1 percent of wholesale value for all finfish and shellfish landings in the ULM. The total weight of all finfish and shellfish landings in this bay system in 1999 was 1,470,939 pounds, or 5.7 percent of the weight of all such landings for all Texas bay systems in 1999 (25.7 million pounds). Black drum represented 1,463,048 pounds (or approximately 99.5 percent) of the weight of all ULM finfish and shellfish landings in 1999 (Auil-Marshalleck et al., 2001).

Table 3-18 compares the commercial fishing landings of the LLM with all Texas bay systems in 1999. The total wholesale value for all finfish and shellfish landings in the LLM system in 1999 was $659,359, or 2.0 percent of the wholesale value of all such landings for all Texas bay systems in that same year ($32.6 million). For this bay system, black drum had by far the greatest wholesale value, worth $438,656 in 1999, or 66.5 percent of wholesale value for all finfish and shellfish in the LLM. Flounder and blue crab also represented substantial shares of the overall wholesale value of finfish and shellfish from landings in this bay system, at $138,142 (21.0%) and $50,769 (7.7%) in 1999, respectively. The total weight of all finfish and shellfish landings in this bay system in 1999 was 687,368 pounds, or 2.7 percent of the weight of all such landings for all Texas bay systems in 1999 (25.7 million pounds). Black drum and blue crab landings represented the greatest share of the weight of all LLM finfish and shellfish landings in 1999, at 528,244 pounds (76.9%) and 70,670 pounds (10.3%), respectively (Auil-Marshalleck et al., 2001).

Recreational fisheries also play an important role in the State's, and, in particular, the south Texas coast's economies. In 1991, recreational boaters spent more than $1 billion fishing in Texas' waters, generating more than $72 million in State sales tax with about a third of the state's recreational fishing occurring in coastal waters (TCMP, 1996). The CMP (1996) reported that recreational boat owners in Texas originate more than 2.4 million boat trips in coastal waters per year and that saltwater recreational fishing resulted in $200 million in earnings and supported almost 11,000 jobs in coastal areas in 1991 alone. It was documented that the LLM supported the largest percentage of red drum caught by private-boat fishermen for the period of 1982–1992 (Warren et al., 1994). In addition, the LLM maintained the highest percentage of coast-wide bay and pass party-boat fishing pressure (26%) and landings (24%)

TABLE 3-17

TRENDS IN COMMERCIAL FISHERY LANDINGS - UPPER LAGUNA MADRE
COMPARED WITH ALL TEXAS BAY SYSTEMS, 1999

	Upper Laguna Madre						All Texas Bay Systems	
	Weight (lbs) of fish landed	Percent of total weight of all Lower Laguna Madre finfish and shellfish	Percent of total weight from all Texas bay system landings	Wholesale value of fish landed	Percent of total wholesale value from all Lower Laguna Madre finfish and shellfish	Percent of total wholesale value from all Texas bay system landings	Weight (lb x 1,000) from all Texas bay system landings	Wholesale value ($ x 1,000) from all Texas bay system landings
Black drum	1,463,048	99.5%	52.3%	$1,501,830	99.1%	55.8%	2,798.5	$2,689.8
Flounder	1,368	0.1%	0.5%	$1,752	0.1%	0.3%	284.2	$597.1
Sheeps-head	463	0.0%	0.4%	$266	0.0%	0.6%	117.4	$47.7
Mullet	289	0.0%	0.5%	$197	0.0%	0.3%	60.2	$68.0
Other finfish	1,470	0.1%	0.8%	$9,333	0.6%	1.7%	173.7	$551.7
Total finfish	146,638	10.0%	4.3%	$1,513,377	99.8%	38.3%	3,434.0	$3,954.2
Brown and Pink shrimp	349	0.0%	0.0%	$461	0.0%	0.0%	5,637.7	$4,857.8
White shrimp	0	0.0%	0.0%	$0	0.0%	0.0%	4,837.0	$8,095.6
Other shrimp	0	0.0%	0.0%	$0	0.0%	0.0%	59.8	$18.8
Total shrimp	349	0.0%	0.0%	$461	0.0%	0.0%	10,534.6	$12,972.2
Blue crab	3,916	0.3%	0.1%	$2,171	0.1%	0.1%	6,471.9	$4,294.7
Eastern oyster	0	0.0%	0.0%	$0	0.0%	0.0%	5,183.3	$11,216.4
Other shellfish	36	0.0%	0.0%	$36	0.0%	0.0%	86.5	$151.3
Total shellfish	4,301	0.3%	0.0%	$2,668	0.2%	0.0%	22,276.4	$28,634.5
Total finfish and shellfish	1,470,939	100.0%	5.7%	$1,516,045	100.0%	4.7%	25,710.4	$32,588.8

Source: Auil-Marshalleck et al., 2001.

TABLE 3-18

TRENDS IN COMMERCIAL FISHERY LANDINGS - LOWER LAGUNA MADRE
COMPARED WITH ALL TEXAS BAY SYSTEMS, 1999

	Lower Laguna Madre						All Texas Bay Systems	
	Weight (lbs) of fish landed	Percent of total weight of all Upper Laguna Madre finfish and shellfish	Percent of total weight from all Texas bay system landings	Wholesale value of fish landed	Percent of total wholesale value from all Upper Laguna Madre finfish and shellfish	Percent of total wholesale value from all Texas bay system landings	Weight (lb x 1,000) from all Texas bay system landings	Wholesale value ($ x 1,000) from all Texas bay system landings
Black drum	528,244	76.9%	18.9%	$438,656	66.5%	16.3%	2,798.5	$2,689.8
Flounder	61,500	8.9%	21.6%	$138,142	21.0%	23.1%	284.2	$597.1
Sheeps-head	2,712	0.4%	2.3%	$1,618	0.2%	3.4%	117.4	$47.7
Mullet	13,858	2.0%	23.0%	$20,080	3.0%	29.5%	60.2	$68.0
Other finfish	4,305	0.6%	2.5%	$6,939	1.1%	1.3%	173.7	$551.7
Total finfish	610,619	88.8%	17.8%	$605,434	91.8%	15.3%	3,434.0	$3,954.2
Brown and Pink shrimp	0	0.0%	0.0%	$0	0.0%	0.0%	5,637.7	$4,857.8
White shrimp	0	0.0%	0.0%	$0	0.0%	0.0%	4,837.0	$8,095.6
Other shrimp	0	0.0%	0.0%	$0	0.0%	0.0%	59.8	$18.8
Total shrimp	0	0.0%	0.0%	$0	0.0%	0.0%	10,534.6	$12,972.2
Blue crab	70,670	10.3%	1.1%	$50,769	7.7%	1.2%	6,471.9	$4,294.7
Eastern oyster	0	0.0%	0.0%	$0	0.0%	0.0%	5,183.3	$11,216.4
Other shellfish	6,079	0.9%	7.0%	$3,156	0.5%	2.1%	86.5	$151.3
Total shellfish	76,749	11.2%	0.3%	$53,925	8.2%	0.2%	22,276.4	$28,634.5
Total finfish and shellfish	687,368	100.0%	2.7%	$659,359	100.0%	2.0%	25,710.4	$32,588.8

Source: Auil-Marshalleck et al., 2001.

from 1988 to 1998, while the ULM was responsible for 17 percent of coast-wide fishing pressure and 17 percent of landings for the same time period (Campbell, 2002).

3.12.2.2 Recreation and Tourism

The natural resources of the Laguna Madre, although not as heavily utilized as other areas of the Texas coast still provide extensive recreational opportunities. Activities such as fishing, birdwatching, waterfowl hunting, windsurfing, camping, boating, jet skiing, swimming, shelling, and beach combing produce recreational opportunities that result in substantial economic benefits for the area. The sport-boat fishing industry supplies the majority of these economic benefits in the Laguna Madre. Tourism is also a major industry in the area and birdwatching is a favorite pastime of many visitors. Several of the birds found in the Laguna Madre and Rio Grande Valley are found nowhere else in the U.S. and serve as a major attraction for birdwatchers from around the world. The total economic impact from tourism and related industries on the Laguna Madre regional economy in 1995 was approximately $289.8 million in output with 6,605 related jobs (Tanyeri-Abur et al., 1998). With the increasing number of users, impacts to natural resources have been occurring more rapidly over time. Increased amounts of marine debris and bay bottom disturbances are the types of impacts that are occurring in the Laguna Madre due to increasing human-related activities.

3.12.2.3 Waterborne Transportation

A large percentage of the economic activity in the region is linked to waterborne commerce via the use of shipping or pipelines. To address the economic issues of waterborne transportation along the GIWW, a special study was authorized by the USACE for the ICT. According to this study, an average of 2.25 million tons of freight per year was transported via the GIWW below Corpus Christi during the 1994 to 1996 period (Fuller and Fellin, 1998). During this time period, 64 percent of all tonnage moving on the GIWW below Corpus Christi involved refined petroleum products, while fertilizer, sand, gravel, iron and steel products, and sugar each composed from 6 to 10 percent of the shipments (Fuller and Fellin, 1998). In 2000, the total freight transported via the GIWW below Corpus Christi was 2.2 million tons, representing slightly lower total cargo than reported in the previous 3 years (Waterborne Commerce Statistics Center, 2000).

Fuller and Fellin (1998) concluded that closing the GIWW below Corpus Christi would lead to approximately an $11 million per year increase in transportation costs, over current conditions, nearly doubling the total transportation and shipment costs associated with the current transport of cargo on this section of the GIWW. The study also evaluated the economic impact of closing the GIWW if a proposed pipeline transported petroleum products from Corpus Christi to the lower Rio Grande Valley. Although the study did not quantify the total transportation costs of these scenarios, it did estimate that transportation costs would increase by $5 million per year if the GIWW were to close in the event that the pipeline is built (Fuller and Fellin, 1998). Fuller and Fellin (1998) summarize their findings by stating: "although modest quantities of commodities/products are currently transported via the examined waterway, its closure would appear to have important implications for selected enterprises that depend on the transportation service of the shallow draft barge."

Another important consideration with waterborne transportation is the potential for accidental leaks or spills. The potential for waterborne accidents within the Laguna Madre includes all types of operators including barges, towboats, harbor tugs, shrimp trawlers, passenger vessels, supply boats, ferries, and recreational vessels. The U.S. Coast Guard Marine Safety Office located in Corpus Christi is responsible for enforcing vessel safety and operational rules for the Laguna Madre. In addition, the Coast Guard serves as the Federal on-scene coordinator responding to petroleum or chemical spills in the Laguna Madre. The state oil spill response coordination is delegated to the GLO.

3.12.3 Land Use

For the purposes of this section, the study area has been defined differently than for other sections of this document. The study area, for this section, captures approximately 3 miles of water/land area, on each side of the GIWW, east and west, along the entire length of the Laguna Madre reach of the GIWW. This stretch of the GIWW extends 117 miles in length, from the JFK Causeway at the north to the Queen Isabella Causeway at the south. This study area buffer allows for land use analysis within the water/land areas that are closest to the preferred alternative. The study area (as defined for this section) is approximately 710 square miles in area and includes portions of Cameron, Nueces, Willacy, Kleberg and Kenedy counties, Texas. The study area includes areas of Padre Island, the ULM and LLM, the mainland Texas coastline and the entrance to Baffin Bay. Also in the vicinity of the study area are five municipalities with populations greater than 2,000: Brownsville, San Benito, Port Isabel, and South Padre Island in Cameron County and Corpus Christi in Nueces County. Willacy County, Kleberg County, and Kenedy County do not contain any cities with populations greater than 2,000 that are within relative proximity to the study area.

The most currently available land use coverages were obtained from a variety of public agencies and private entities, and included 1990 U.S. Geological Survey (USGS) land use/land cover coverages (based on satellite imagery interpretation) (USGS, 1990), TxDOT county roads coverage (TxDOT, 1999a), and 1999 parks coverage (TxDOT, 1999b). Additional state parks and wildlife management areas and wildlife refuge coverages for Texas were obtained from GLO (1997). Urban development within the study area that has occurred since 1990 was interpreted from DOQQs for the study area (Texas Geographic Information Council, 1995). Figures 3-4a through f depict the prominent land use categories represented in the project area.

Land use within the study area is dominated by agricultural and ranching activities. Agriculture has historically been, and continues to be, an important part of the economy despite the highly variable rainfall. Nearly 19,000 jobs were estimated to be directly or indirectly related to agriculture within the project area counties and Hidalgo County (Tanyeri-Abur et al., 1998). The majority of the agricultural land is managed as rangeland and used for a variety of purposes, including livestock production, wildlife habitat, and recreation. This area also consists of expansive areas owned and maintained by the Federal government, including the LANWR and the PINS. Although freshwater inflow to the Laguna Madre is limited, these agricultural/rangeland watersheds are responsible for the majority of freshwater input into the Laguna Madre.

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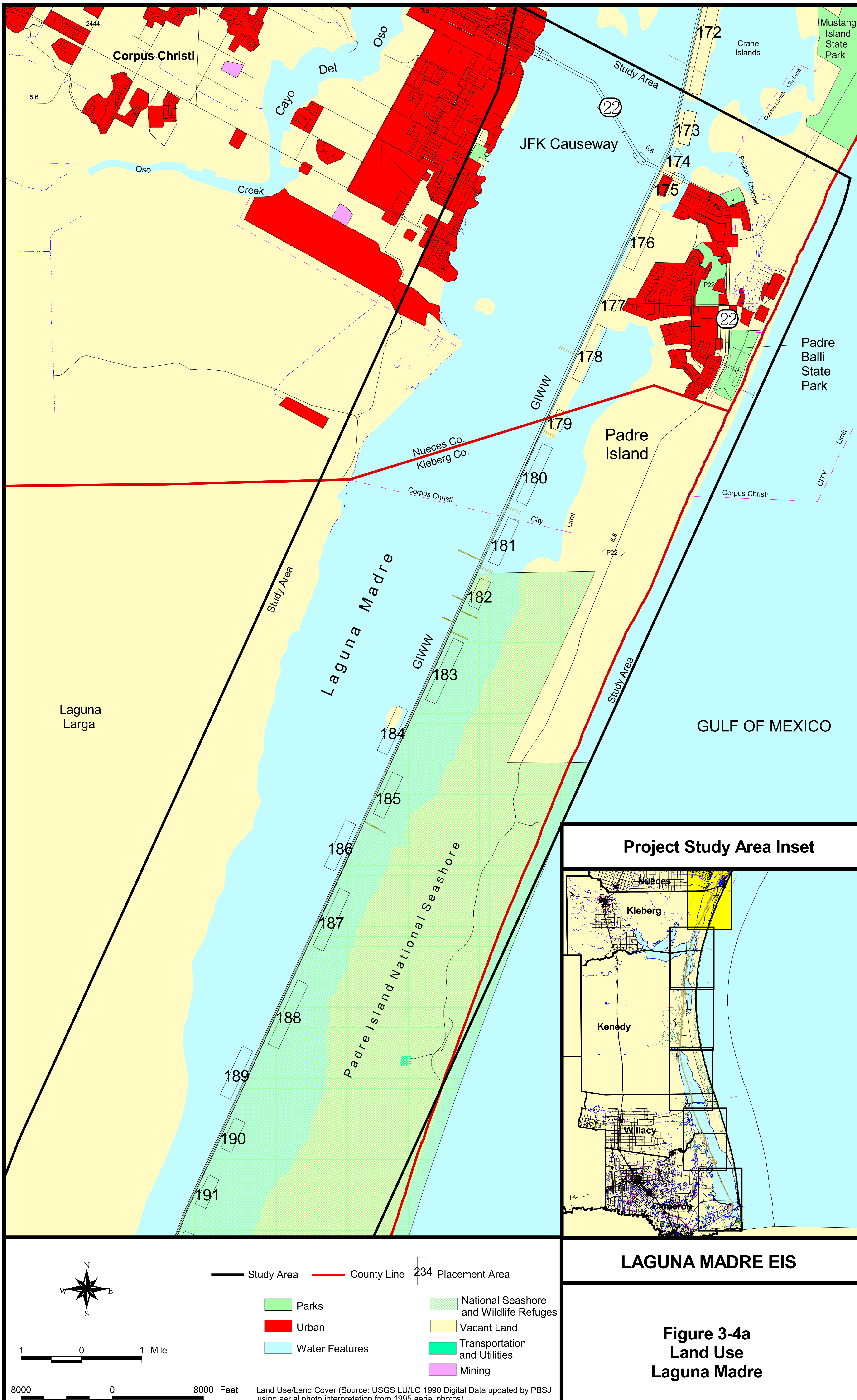

Figure 3-4a
Land Use
Laguna Madre

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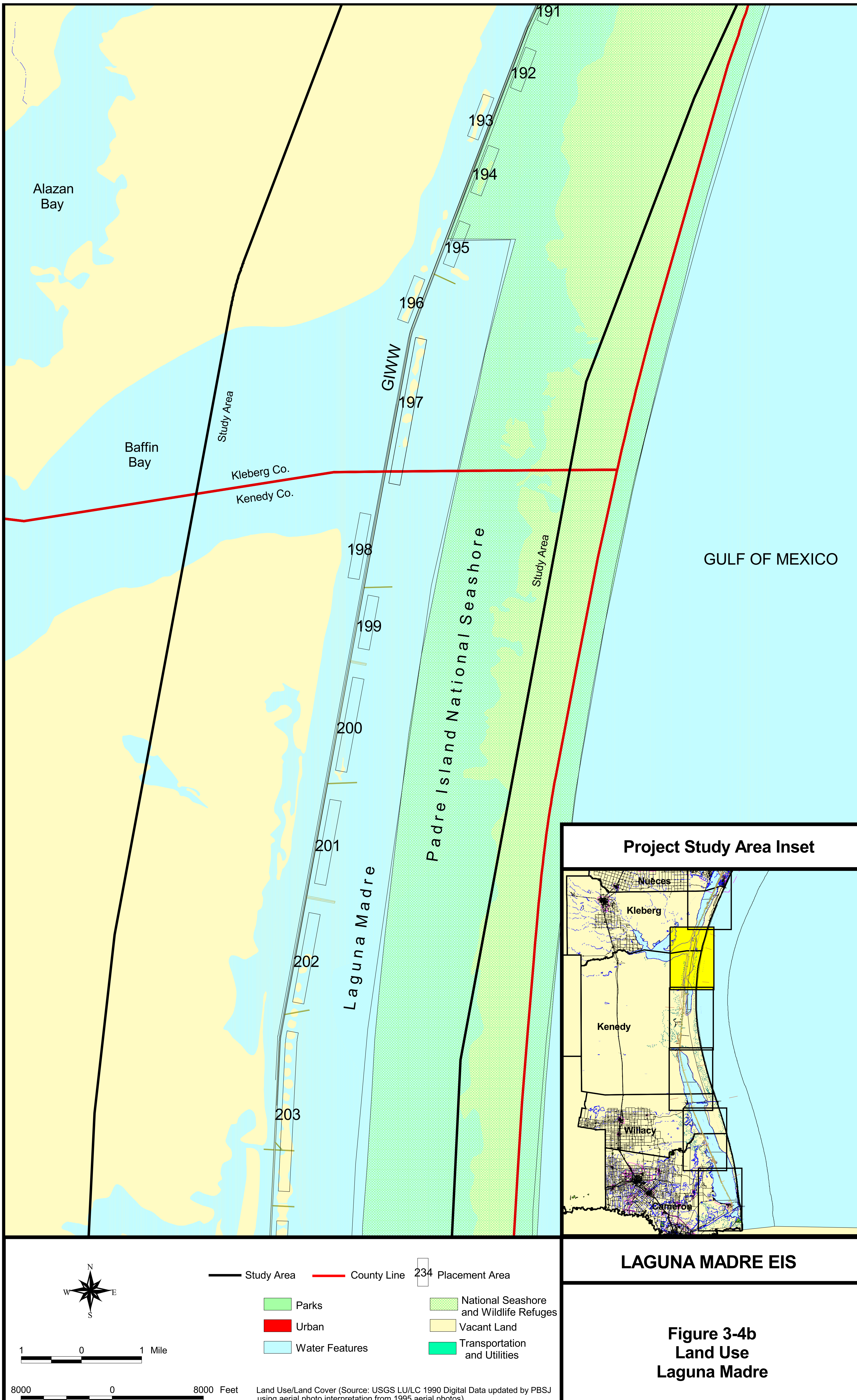

Figure 3-4b
Land Use
Laguna Madre

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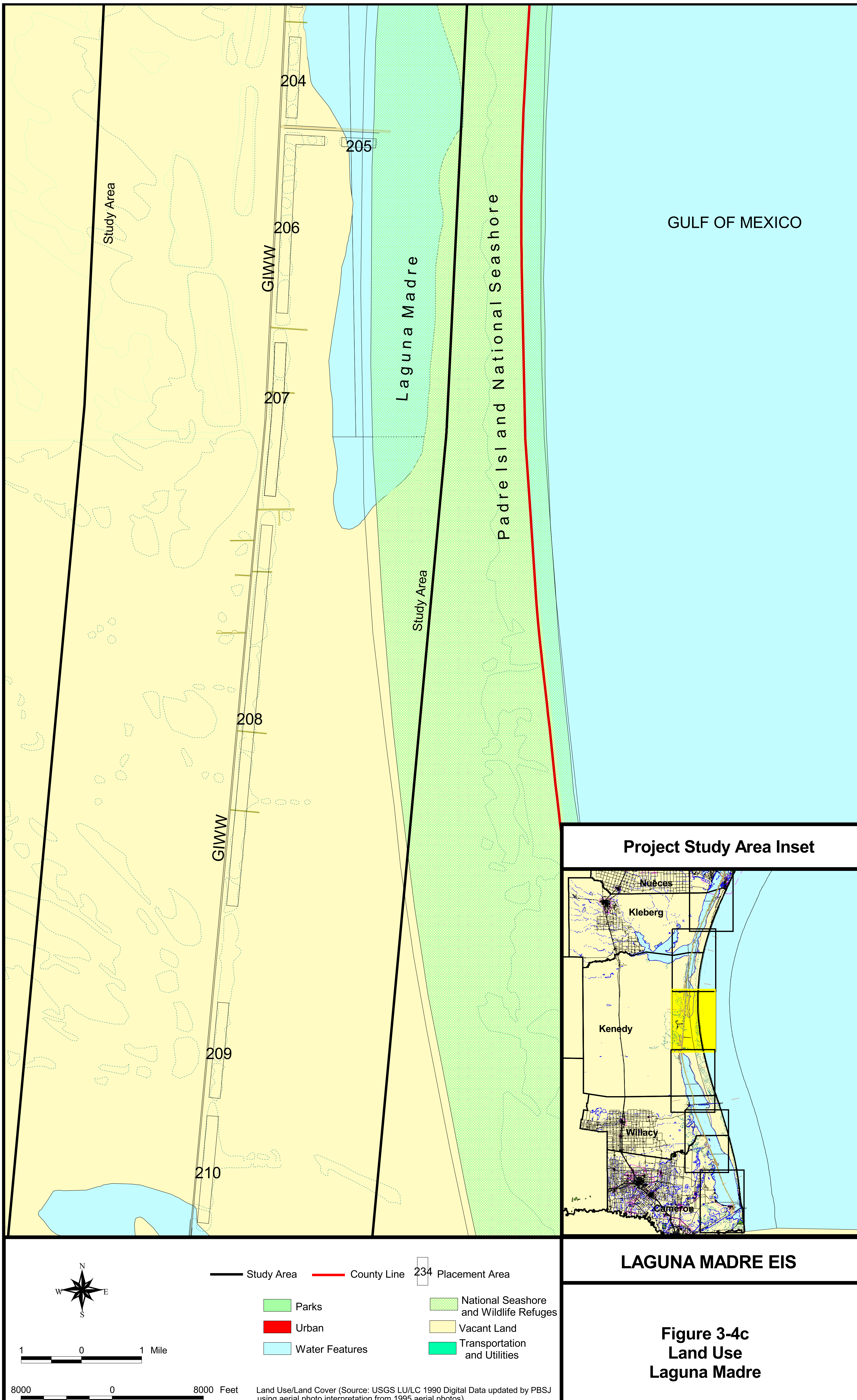

LAGUNA MADRE EIS

Figure 3-4c
Land Use
Laguna Madre

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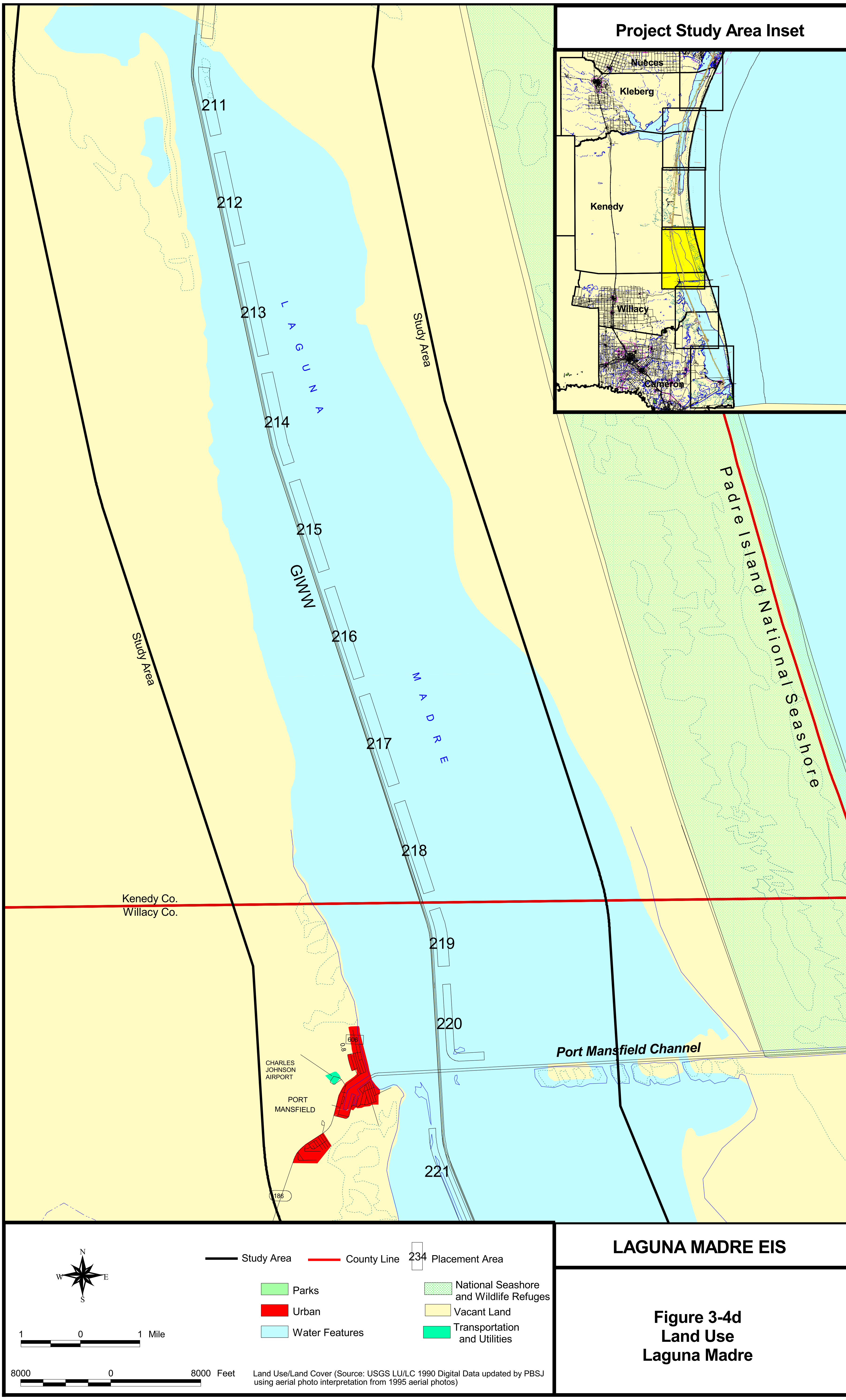

Land Use/Land Cover (Source: USGS LU/LC 1990 Digital Data updated by PBSJ using aerial photo interpretation from 1995 aerial photos)

LAGUNA MADRE EIS

Figure 3-4d
Land Use
Laguna Madre

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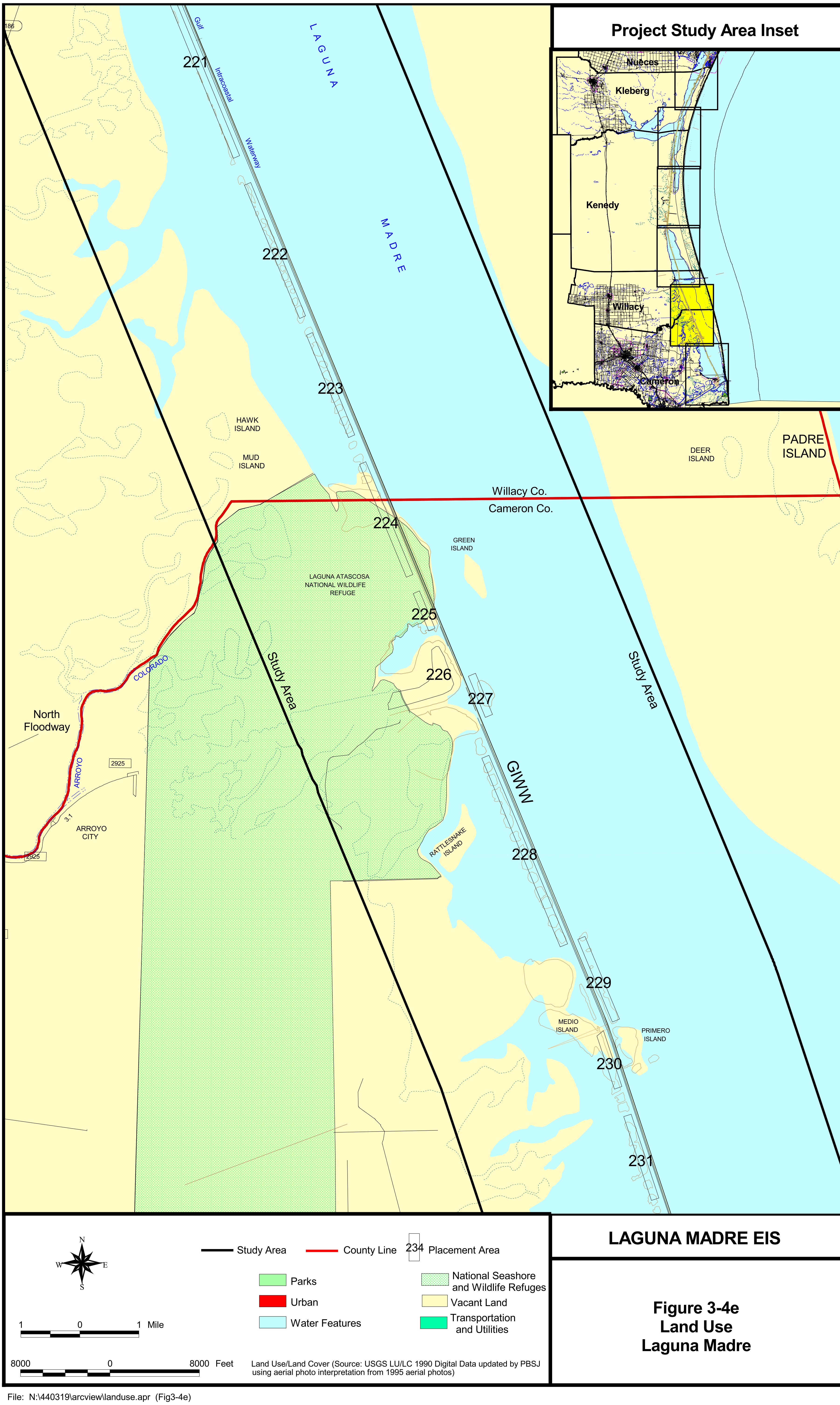

LAGUNA MADRE EIS

Figure 3-4e
Land Use
Laguna Madre

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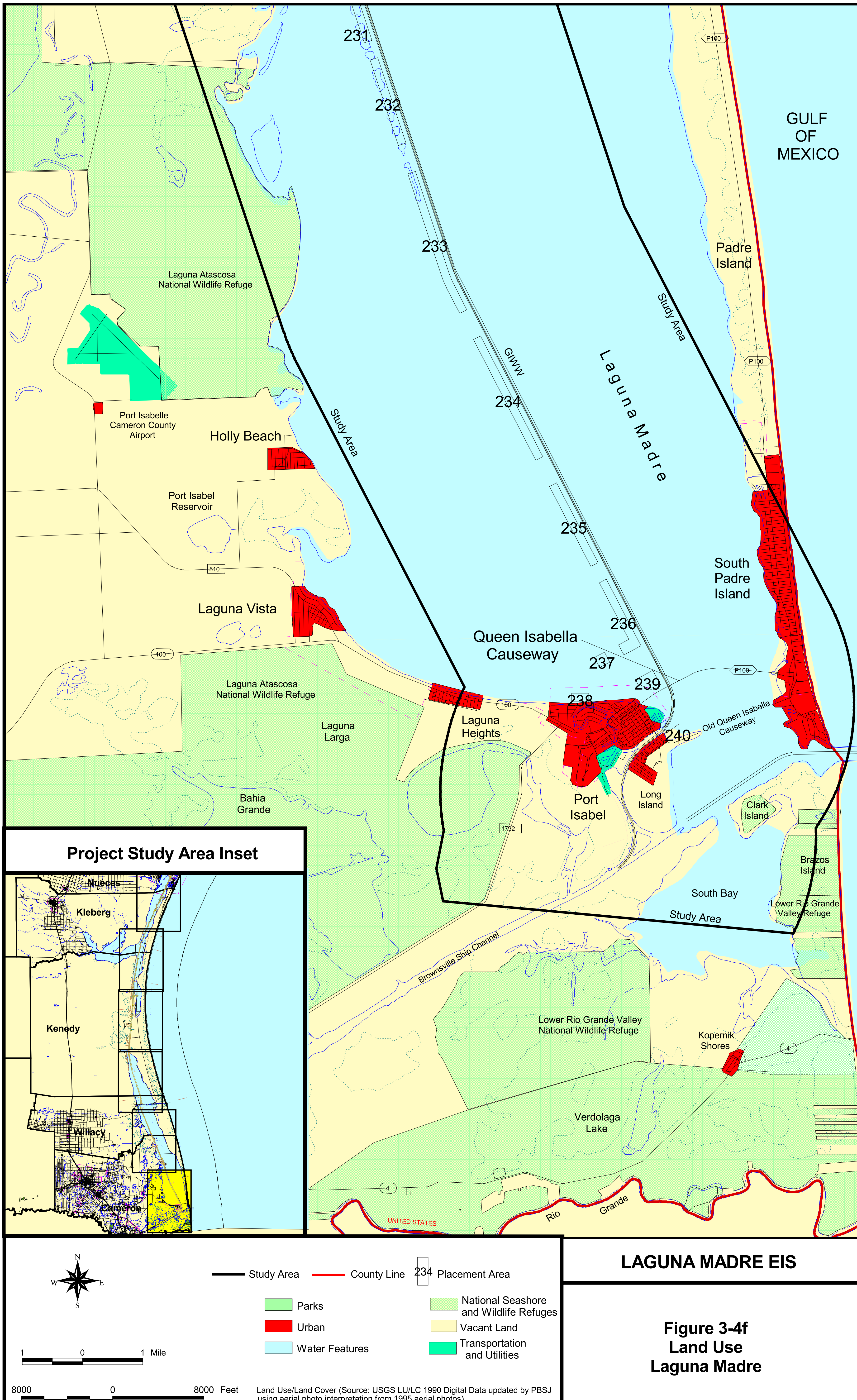

LAGUNA MADRE EIS

Figure 3-4f
Land Use
Laguna Madre

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In the vicinity of the ULM (Kenedy and Kleberg counties), approximately 64 percent of the land is used for agriculture, of which about 96 percent is used for range and pasture land, and the remaining 4 percent is cultivated (Brown et al., 1977). Cotton and grain sorghum are the two major agricultural crops, and cattle are the principal livestock raised in the region. Cultivated agriculture is currently the predominant land use in the lower Rio Grande Valley. Within Cameron, Hidalgo, and Willacy counties, between 54 and 62 percent of land is used as cropland and related agriculture, while rangeland constitutes approximately 30 to 35 percent of the land use (Texas Water Commission, 1990). Fruits, vegetables, grain sorghum, and cotton are the principal irrigated crops in the lower Rio Grande Valley. Additional agricultural activities include agribusiness firms that supply production inputs, process commodities, and provide services. Over the project area counties and Hidalgo County, approximately $488 million resulted from direct impacts of agriculture between 1993 and 1995 (Tanyeri-Abur et al., 1998).

PINS extends along Padre Island from just south of Corpus Christi to the Port Mansfield Channel, separating the Gulf of Mexico from the Laguna Madre. Padre Island, considered the longest undeveloped barrier island in the world, is approximately 70 miles long with 65.5 miles of Gulf of Mexico beach, encompassing 130,434 acres on Padre Island. Bordering the Laguna Madre are coastal prairies and grasslands, ephemeral marshes and ponds, and mud flats. PINS provides no public or commercial thoroughfares within the park boundaries, and major recreational activities within the seashore include fishing, camping, bird watching, and windsurfing. Camping is available at five primitive camping areas. The NPS reported 663,890 recreational visits at the PINS in 2001 (NPS, 2002).

The LANWR consists of 45,187 acres in Cameron County along the western shoreline of the LLM and is owned and managed by the FWS. This broad, level preserve is characterized by meandering resacas (old Rio Grande oxbows), lomas, and coastal salt flats, and Lake Atascosa (for which the LANWR is named). The FWS also manages areas of cropland and grassland within LANWR that provide additional habitat for birds and mammals. The LANWR is very popular with birdwatchers and wildlife viewers, who visit this area to see migratory and resident birds and wildlife that are found in few other places. A few tour roads, service roads, and hiking trails provide public access through the refuge. Camping is allowed in a couple of areas just outside of LANWR boundaries (FWS, 2002d).

The vast regions of sparsely populated privately owned farm and ranch land and Federally protected lands (LANWR and PINS) have provided protective buffers to the project area, limiting development along the shoreline and, as a result, the ULM and LLM have remained relatively pristine (Davis et al., 1996).

3.12.4 Environmental Justice

In compliance with Executive Order (EO) 12898 "Federal Action to Address Environmental Justice (EJ) in Minority Populations and Low-Income Populations," an analysis has been performed to determine whether the preferred alternative will have a disproportionate adverse impact on minority or low-income population groups within the project area. The EO requires that minority and low-income populations do not receive disproportionately high adverse human health or environmental impacts and requires that representatives of minority or low-income populations, who could be affected by the project, be involved in the community participation and public involvement process.

The data used in this study to determine the potential for disproportionate impacts to low-income and/or minority populations within the project study area are presented in Tables 3-10 and 3-14. The information is based on 2000 USBOC state, county, and census tract level data for ethnicity and income.

Ethnic and poverty demographics were examined within the study area cities and the study area counties. Where appropriate, the study area cities' demographics will be compared with the study area counties' demographics.

In terms of ethnicity, the average percentage of African Americans within the Cities of Brownsville (0.2%), San Benito (0.1%), Port Isabel (0.3%) and South Padre Island (0.6%) are all within three tenths of the percentage of African American's found in Cameron County (0.3%), yet the percentage within Cameron County and the study cities within it are all far under that of the State (11.5%). The average percentage of Hispanics within the Cities of Brownsville (91.3%), San Benito (86.9%), Port Isabel (74.4%) and Cameron County (84.3%), are more than twice as high was the percentage of Hispanics in the State (32.0%). Only the city of South Padre Island (22.8%) has a percentage of Hispanics that is lower than that of the State. The average percentages of "other" races within the Cities of Brownsville (0.8%), San Benito (0.5%), Port Isabel (0.8%) and South Padre Island (1.6%) and within Cameron County (1.0%) are far under the percentage of "other races" within the State (17.6%).

The average percentage of African Americans within the City of Corpus Christi (4.5%), is about equal to that of Nueces County (4.1%), but less than half of that of the State. The average percentage of Hispanics within the City of Corpus Christi (54.3%), and Nueces County (55.8%), are far greater than the percentage of Hispanics in the State. The average percentages of "other" races within the City of Corpus Christi (2.7%) and within Nueces County (2.5%) are far under the percentage of "other races" within the State.

The average percentages of African Americans within Willacy (2.0%), Kleberg (3.5%) and Kenedy Counties (0.0%) are all well under the percentage of African Americans in the State. The average percentage of Hispanics within Willacy (85.7%), Kleberg (65.4%) and Kenedy Counties (79.0%), are more than twice as high was the percentage of Hispanics in the State. The average percentages of "other" races within Willacy (0.6%), Kleberg (2.6%) and Kenedy Counties (0.7%) are far under the percentage of "other races" within the State.

The average percentage of people living below the poverty line in the cities of Brownsville (36.0%), San Benito (32.7%), and Port Isabel (27.3%) are all close to the percentage of people living below the poverty line found in Cameron County (33.1%), yet the percentage within Cameron County and the study cities within it are all far above that of the State (15.4%). The average percentage of people living below the poverty line in the City of South Padre Island (12.0%) is lower than the County and the State.

The average percentage of people living below the poverty line within the City of Corpus Christi (17.6%), is roughly equal to that of Nueces County (18.2%), and slightly greater than that of the State (15.4%).

The average percentages of people living below the poverty line within Willacy (33.2%) and Kleberg Counties (26.7%) are well above the percentage of people living below the poverty line in the State. The average percentage of people living below the poverty line in Kenedy County (15.3%) is roughly the same as the State.

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4.0 ENVIRONMENTAL CONSEQUENCES

4.1 ENVIRONMENTAL SETTING

Neither alternative would have adverse impacts on the regional physiography, geology, and climate. The DMMP alternative, like the No-Action alternative, would continue maintenance dredging of the GIWW between the JFK Causeway and the Old Queen Isabella Causeway using cutterhead suction dredges. Most dredged maintenance material would be placed onto existing designated placement areas. New and extended placement areas would be located such that shoaling and sedimentation would be reduced. However, some PAs are or would be managed as emergent habitats (see Section 2.11 for a discussion and summary of the DMMP, which is included as Appendix A).

4.2 WATER QUALITY

The Laguna Madre is designated as water body No. 2491 by the TCEQ. According to the 2000 Clean Water Act Section 303(d) List (TCEQ, 2002a), designated uses include aquatic life use, contact recreation use, general use, fish consumption use, and oyster waters use. These uses are fully supported except for aquatic life use, which is partially supported due to depressed dissolved oxygen (DO) concentrations in the upper third of the Laguna Madre and a localized area near the mouth of the Arroyo Colorado. Oyster waters use is not supported due to potential contamination by human pathogens. The Draft 2002 Texas Water Quality inventory (TCEQ, 2002b) indicates that all uses are now fully supported, except for aquatic life use which remains partially supported. This determination is based mainly on a lack of adequate data concerning 24-hour DO levels needed to conclude whether the criterion is supported. The Draft Summary of the 2002 Texas Water Quality Inventory (TCEQ, 2002c), however, indicates that some areas which previously were partially supporting aquatic life use are now fully supporting this use. These areas include the Upper Laguna Madre near Packery Channel Park, the area near the upper end of the Padre Island National Seashore, and the area around the mouth of the Arroyo Colorado.

The No-Action alternative may or may not affect DO concentrations in the water column at PAs (Brown and Clark, 1968; Pearce, 1972; Hopkins, 1972; May, 1973; Windom, 1972; Wakeman, 1974). May (1973) found that although the water column DO did not change, there was a temporary decrease in DO at the water/sediment interface in the areas of mud flow. He also found little apparent difference in the immediate oxygen demand between recently deposited sediments from dredged material placement and other sediments. May (1973), Jones and Lee (1978), Peddicord (1979), and Lee (1976) agree that high total oxygen demand, as measured in the laboratory, does not necessarily lead to oxygen depletion upon placement since only a small part of the oxygen demand is exerted at placement. This would apply to both the No-Action and the DMMP alternative, but since the DMMP alternative includes less unconfined open-bay placement, a concomitant decrease in any consumption of oxygen would be expected. However, it should be noted that low oxygen was not found as a concern by studies of water chemistry of the Laguna Madre (EH&A 1997a). The Laguna Madre, Segment 2491, was identified on the 2000 303(d) List by TCEQ as partially supporting the aquatic life use due to depressed dissolved oxygen in several areas. The segment is also listed in category 5C (additional data and information will be collected before a TMDL is scheduled) on the 2002 303(d) List (Source TCEQ website three.state.tx.us/water/quality/02_twqmar/02_305b/2491_fact.pdf).

In laboratory studies, Burk and Engler (1978) found that there were only small releases of metals into the water column during dredged material placement because of the insolubility of most metal oxides. They found that, if present in sufficient quantity, hydrous iron oxide will scavenge other metals from the water column. The lack of release of metals into the water column was confirmed by field studies conducted by the USACE WES (Wright, 1978). These studies found that only manganese was found to be released to any extent in studies off Galveston, Texas; in Lake Erie just offshore from the Astabula River Harbor, Ohio; and in the nearshore Pacific Ocean off the Columbia River, Oregon. Even for manganese, however, ambient concentrations were reestablished in minutes to hours. Phosphorus and nitrogen (mostly as the ammonium ion) were also released but, again, concentrations returned to normal within minutes to hours (Wright, 1978).

The most obvious impact of the No-Action alternative to the estuarine water column is turbidity associated with maintenance dredging and placement, which has been shown to reduce primary production in laboratory studies (Sherk, 1971). Field studies, however, have shown essentially no biological impacts from turbidity (Odum and Wilson, 1962; May, 1973). May (1973) found that on a still day, the turbidity plume from an open-bay PA was detectable from an aircraft only a little more than one mile down current. On days when winds caused natural turbidity in an estuarine system, the plume was not detectable more than a few hundred yards down current from active disposal in an open-bay PA. Turbidity increased to 500 to 800 ppm in the dredged material plumes (Wright, 1978), but was quickly diluted. However, these sites were in the nearshore Gulf of Mexico, Lake Erie, or Pacific Ocean and dilution rates likely do not correspond to the Laguna Madre. Onuf (1994), found elevated turbidity at the PA 15 months after disposal; at sites up to 1.2 km from the PA; and, of most concern, over seagrass beds adjacent to the PA 16 months after deposition.

In fact, concern has been expressed at Public Hearings and Public Meetings relative to the impact that the present maintenance dredging practice has on total suspended material and, thus, turbidity. Several studies were performed that directly apply to this concern. A brief discussion of these studies is found in the next few paragraphs. More detail can be found in Appendix H and the complete studies are available on the Galveston District webpage (www.swg.usace.army.mil).

EH&A (1997a) reduced and analyzed all large data sets that were available and found few areas that were notable. The cause of these areas of concern may have been real constituent elevation or, as noted in Appendix H, they may have been an artifact of sampling protocols. In any case, what few trends there were showed no evidence of being related to dredging and placement activities. However, the ICT recommended that additional data collection, including water, sediment, and elutriate chemistry, plus bioassays and bioaccumulation studies, should be conducted. The results of the analyses were that the only potential cause for concern was slight toxicity exhibited by an amphipod to the sediment from a GIWW station between the Arroyo Colorado and the North Floodway (EH&A 1998a; LWA 1998).

The reduction, analysis and interpretation of the 1994–1998 CBI data (PBS&J/Ward, 1999; see Section 3.5) also provided data on turbidity in the Laguna Madre and at stations chosen to allow determination of dredging and placement impacts. For example, there was active dredging in the early months of the 4-year data collection. In the LLM, there is a tendency for higher TSS during the dredging periods than prior to or 1 year after dredging ceased. However, while this would appear to be a cause and effect situation, the TSS concentrations were nearly as large in the spring of 1996, when there was no dredging, as during dredging operations. Where an association between TSS and currents appears to exist, it seems to be governed more by current direction than current speed; however, in the LLM, at station LLM1, there is a positive association between wind speed and TSS and a clear correspondence between spikes in wind speed and spikes of TSS. Sheridan (1999) found elevations in turbidity only over the subtidal placement material fluid mud pile. Even 16.5 feet from the edge of the placed material, turbidity was not statistically greater than at seagrass beds 1 kilometer or more away. Morton et al. (1999) found that over 97 percent of the maintenance material was reworked dredged material, so there is obviously transport, which would increase turbidity. However, since PBS&J/Ward (1998) found little correlation with wind speed, until there were spikes of wind, it can be surmised that most transport with very high turbidity takes place during higher wind events and is, therefore, of short duration.

TSS were determined as part of the hydrodynamic/sediment transport modeling to provide information for the ICT. These results were provided as TSS and transformed into isopleths (lines of equal value) of 20 percent surface irradiance reaching the seagrasses, with and without open-bay dredged material placement. The differences in areas for the with- and without OBUC placement were estimated and summed by reach, as acres of impact to seagrass. In Section 3, these acres were assigned a score as were the acres of other areal impacts, and ranged from 0 acres in Reach I to 176 acres in Reach 6. Turbidity was also assigned scores in Section 3 as follows: the with-placement scenario was compared with the without-placement scenario for the sediment transport modeling. If TSS, under these circumstances, increased by more than 25 mg/L for at least 3 months, a minimal negative score was assigned; if by more than 50 mg/L for at least 3 months, an intermediate negative score was assigned; and if my more than 100 mg/L for at least 3 months, the maximum negative score was assigned. However, the average TSS was not higher than 25 mg/L for any 3 months after dredged material placement at any Reach, according to the modeling conducted by the USACE WES (Teeter et al., 2003). Average TSS values above 100 mg/L only occurred in the 119 hours during placement activities. A TSS average above 50 mg/L occurred in Reaches 2 and 4 during the month of simulated placement activities (April 1995), but not after April. These levels of impact category based on potential impacts to seagrasses provided in the preliminary results of the Seagrass Modeling (Burd, 2003b). Therefore, the modeling showed that small impacts were to be expected from turbidity from OBUC dredging and placement. However, since impacts were shown by the modeling and since there have been documented concerns, the ICT recommended eliminating OBUC placement, to the extent possible, and imposed a time restriction on dredging on the remaining PAs to limit the impacts to seagrass. Use of deflectors in the DMMP alternative to direct the material on nonconfined islands, the use of deeper water for some open-bay sites, and partially or completely confining others should reduce turbidity and any associated impacts. Should these limitations prove to aid seagrasses in the Laguna Madre, a decrease in long-term turbidity would be expected to result from the development of these seagrass beds.

4.2.1 Water Exchange and Inflows

Since neither alternative would close the GIWW, neither alternative would impact flows coming into, out of, or between the ULM and the LLM. There would be some minor, local impacts on flows inside the Laguna Madre where channels are opened or widened, but these would not be sufficient to cause significant effects to the ecosystem.

4.2.2 Salinity

Since neither alternative affects freshwater inflow, evaporation, or water exchange, neither alternative will impact salinity in the Laguna Madre system. Widening of some water exchange channels and closing others will have only insignificant, local effects.

4.2.3 Water Chemistry

Under the No-Action alternative, the water quality impacts would continue as they have been in the past, with the turbidity that is associated with dredging and placement and with wave action on newly placed material. Detrimental impacts from chemical contaminants have not been noted in the past and none would be expected under the No-Action alternative.

Fewer impacts to water quality can be expected from the DMMP alternative since there will be less open-bay placement and more confined placement. There will be some minor short-term turbidity during levee construction for the open-bay confined PAs and open-bay semiconfined PAs, but this will be more than overcome, in the long term, from the reduced turbidity associated with the reduction in open-bay placement. Significant detrimental environmental effects to water quality have not been noted in past maintenance operations and are not expected with the preferred alternative.

4.2.4 Brown Tide

Brown tide has persisted in parts of the Laguna Madre for more than 9 years (Tunnel and Judd, 2002). The onset of brown tide occurred during severe freezes in the estuary in 1989 causing a large die-off of fish and benthos, and resulting in increased NH_4^+ concentrations and a subsequent collapse in the zooplankton community resulting in a mono-specific bloom (Buskey, 1997). Sediments collected from the bottom of the GIWW contained large quantities of NH_4^+ (Morin and Morse, 2003). These authors note that resuspension of these sediments could be expected, therefore, to result in the release of a significant amount of NH_4^+ into the water column. Brown tide has adapted to low light, highly turbid waters and preferentially takes up NH_4^+ as a nitrogen source. Morin and Morse (2003) conjectured that NH_4^+ inputs during dredging events, along with light reduction could replicate the original brown tide event in a localized manner. Because nutrients are not rapidly transported out of the Laguna Madre and eliminated, this NH_4^+ load could intensify the brown tide bloom (Morin and Morse, 2003). Therefore, Morin and Morse (2003) state that dredging and dredged material placement operations associated with the No-Action alternative and the DMMP alternative may be expected to cause or exacerbate brown tide in the Laguna Madre, although since less dredged material would be released to the Laguna Madre by the DMMP alternative, this possibility should be reduced. However, it should be noted that, while the brown tide appears to be a recurring phenomenon (Whitledge, 1993), it has not been recorded in the Laguna Madre since the GIWW was dredged in 1949, except for this latest occurrence. Therefore, since the brown tide organism is always present in the Laguna Madre system (Buskey et al., 1996), and maintenance of the GIWW has not caused brown tide events, there must be mechanisms occurring in the Laguna Madre that prevent the hypothesis put forth in Morin and Morse (2003) from becoming reality. Others have noted the release of ammonia from dredged material placement (Windom, 1972), but Morton (1977) notes that "the stimulating effect of the released nutrients on primary production in estuaries may offset the depressive effects of turbidity."

4.3 SEDIMENT QUALITY

Since the sediment quality of maintenance material has shown no indication of a cause for concern, the fact that the DMMP alternative removes more maintenance material from the Laguna Madre system, does not appear to make it preferable to the No-Action alternative from a sediment quality viewpoint.

4.3.1 Toxicity Testing

No indication of toxicity has been determined by past bioassays or bioaccumulation studies, therefore, neither alternative is preferable from a toxicity testing perspective. Under the DMMP alternative, the USACE will conduct appropriate testing of sediment and water column for chemical contaminants.

4.3.2 Sediment Budget

Since the DMMP alternative includes more UCPA options than the No-Action alternative, there should be a local reduction in the amount of resuspended maintenance material and a concomitant decrease in local shoaling. This should lead to a reduction in the frequency of dredging near the confined PAs since refinements to the calculations of Morton et al. (1998) indicate that 97.1 percent of all maintenance dredging is from reworked maintenance material. It was noted in Section 2.9.2 that Teeter et al. (2003) found a 14% reduction in the amount of material that would need to be dredged if all maintenance material were placed offshore or in completely confined PAs. This information was based on Sediment Transport Model runs of a scenario in which all maintenance material was removed from the Laguna Madre versus present practice for an extremely large, one-time placement event and was conducted in an attempt to determine the reduction in dredging frequency to develop comparative costs data. It is also based on data collected over a one year period and could not be used to predict a reduction in dredged material for longer periods without losing confidence in the model's output due to a loss in resolution. Morton's data (Morton et al., 1998) were based on sediment cores that could provide information on a much longer time span, but would not be as accurate over shorter (annual) time periods. Therefore, the information from Teeter (2000) is not directly comparable to Morton et al. (1998) since Morton et al. concluded that 97.1% of all maintenance material is ultimately reworked, but both sets of information do point to a reduction in dredging with increased confinement of maintenance material. However, only future dredging will determine whether all sources and sinks in such a vast system were, or can be, accurately defined and, thus, the amount that the additional confinement of maintenance material will reduce dredging frequency.

4.4 COASTAL COMMUNITY TYPES

4.4.1 Submerged Aquatic Vegetation

4.4.1.1 Impacts

Potential seagrass loss is expected from maintenance dredged material placement resulting in both direct and indirect effects. Direct impacts would result from burial of SAV by the discharged material. Since at least the mid-1970s, scientists have hypothesized that large areas of SAV loss in the Laguna Madre may be indirectly associated with increased turbidity caused from dredged material deposition (Merkord, 1978; Onuf, 1994). Morton (et al., 1998) reported that shoaling of the GIWW is primarily caused by reworking of dredged material. The argument is that fine grained dredged material deposited in a slurry is highly susceptible to resuspension from physical processes, such as waves and currents, may then be carried over SAV beds by waves, currents, changes in circulation patterns, depth, and sediment composition (Pulich et al., 1997; Onuf, 1994, Morton et al., 1998). This increase in suspended sediment would attenuate underwater irradiation (light), one of the predominant factors influencing the growth of seagrass (Dunton et al., 2003; Onuf, 1996a). The light attenuation caused by resuspension of dredged sediments would add to the cumulative affect of other natural light attenuators, such as scattering and absorbance by water, ambient suspended solids, dissolved organic materials, as well as, phytoplankton pigments (Dunton et al., 2003) and could cause SAV loss at the outer limits of meadows in deeper areas of the Laguna Madre (Onuf, 1994). It should also be noted that aside from light attenuation, other physical factors influencing seagrass distribution and health include salinity, nutrient limitations, and sediment contaminants (including sulfide and ammonium), sediment composition, and temperature (Onuf, 1996a).

A review of the scientific literature found that very little scientific study had been conducted on the effects of dredging on SAV in the Laguna Madre. Onuf (1994), one of the most cited papers on this issue, attributed seagrass loss in the deeper portions of the LLM from 1965–1974 to increasing water turbidity from maintenance dredging, based on his analysis of studies conducted by McMahan (1969), Merkord (1978), and Quammen and Onuf (1993). His analysis indicates that the change in distribution in the LLM correlates with the frequency and timing of dredging activities. He states that in the 5 years prior to the 1974 study by Merkord (1978), dredging activities were much greater in intensity than those 5 years leading up to the 1965 survey (McMahan, 1969) in areas recording major reduction in seagrass cover. By the time Quammen and Onuf (1993) surveyed in 1988, some recovery was evident where prior dredging activity was less frequent, but additional decline was found where dredging activities had increased.

Onuf (1994) used a 5-year period of dredging activity (defined as length of channel dredged per 20,000-foot length of the GIWW) and compared this to seagrass loss, from Port Isabel to the Land Cut. Onuf (1994) also found elevated turbidity levels at disposal sites in the LLM 15 months after deposition, with detectable effects 0.7 mile from the closest dredged material disposal site. In seagrass meadows, the effects were evident up to 10 months after the disposal event. Because turbidity is closely associated with the amount of material available for resuspension, an additional analysis of the dredging record was conducted to determine cubic yards of material removed from different sections of the GIWW. If dredging quantity versus distance is compared along the GIWW (Figure 4-1) for different time periods of 5-year vs. 4-year vs. 3-year (Figures 4-1, 4-2, and 4-3), the same pattern found in Figure 2 of Onuf (1994) is not always apparent. For instance, the dominance reported by Onuf (1994) of the 1969–1974 time period over the 1960–1965 time period north of the Arroyo Colorado (roughly at 155,000 feet) is not evident in the 5-year dredge quantity record. In fact, the dredging quantities in the 1960–1965 period were greater than the 1969–1974 period for 13 GIWW segments, while the opposite was true only for two segments. Therefore, one could reasonably expect less turbidity in the 1969–1974 period in the northern LLM and less turbidity-related seagrass loss. As a comparison of the three figures shows, different time intervals also provide different dominance patterns, especially in the southern LLM.

A review by Teeter et al. (2003) found that the overall data do not support the conclusion that maintenance of the GIWW is the primary factor in the large scale loss of SAV in the LLM, pointing to 1) dredging records do not show an upward trend in this area which would be expected with less vegetation, 2) LANDSAT photographs show that the bare, high-turbidity area had appeared by 1972, and 3) other areas, such as Emmord's Hole have fluctuated between vegetated and non-vegetated. Perhaps Morton (et al., 1998) best summed up the status of the science: "Deposition of dredged material taken from the GIWW during the past 50 years has eliminated seagrass habitat in some areas of the lagoon and created new habitat in others. However, it is uncertain if reworking of the dredged material is a significant factor in the reported losses in seagrass from southern Laguna Madre, or if other factors are responsible or at least contribute to the losses."

Onuf (1994) also states that if the frequency and duration of the dredging and placement events persist and continual turbidity extends beyond immediate impact areas, then outer limits of seagrass beds will diminish, and if recurrence of dredging occurs prior to seagrass recovery, then losses will be permanent. This conclusion is compatible with the results of Sheridan (1999) for what he describes as the Maximum Impact Habitat, which is essentially at the center of the subtidal fluid mound of mud, where turbidity would be expected to return to normal conditions within 18 months. Sheridan (1999) found that TSS was never statistically greater over seagrass beds, even if they were within 16.5 feet of the edge of the dredged material fluid mud flow. However, Sheridan (1999) took no samples until at least 6 months after dredging and placement.

Because of the paucity of scientific studies regarding the affects of dredging on SAV in the Laguna Madre, the ICT recommended the USACE fund the development of an integrative seagrass model (see Appendix H) to help address the issue. The seagrass models conducted to provide information for the ICT (Burd, 2003a) found that only direct burial caused the loss of seagrass. However, the model simulations and in situ measurements strongly suggest that dredging operations are very likely to have a measurable negative impact on seagrass biomass over a limited area near the dredged deposit (Dunton et al., 2003). With and without dredging scenarios showed only a slight increase in TSS within

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Figure 4-1
GIWW Maintenance Quantities - LLM (5-Year Period)

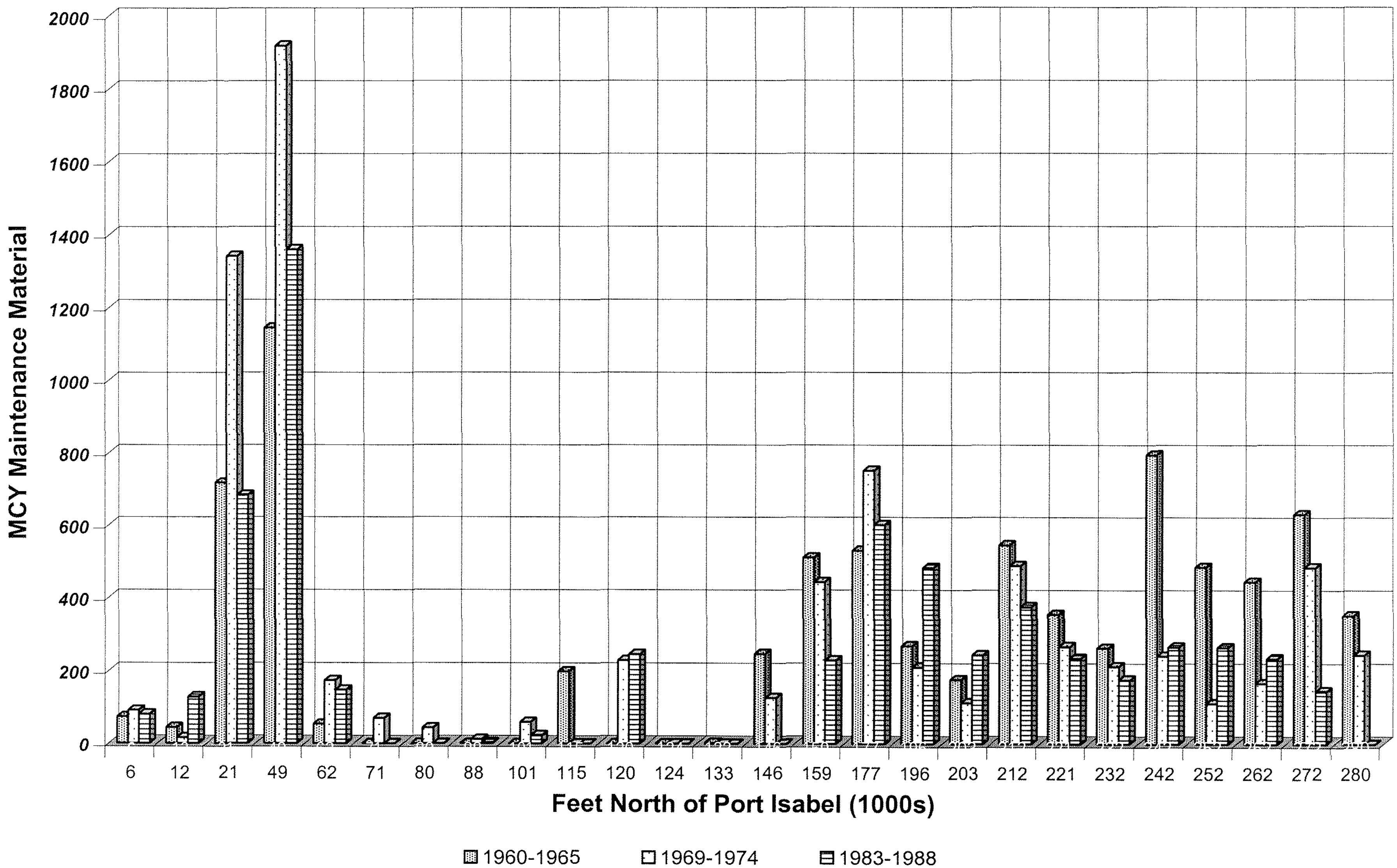

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Figure 4-2
GIWW Maintenance Quantities - LLM (4-Year Period)

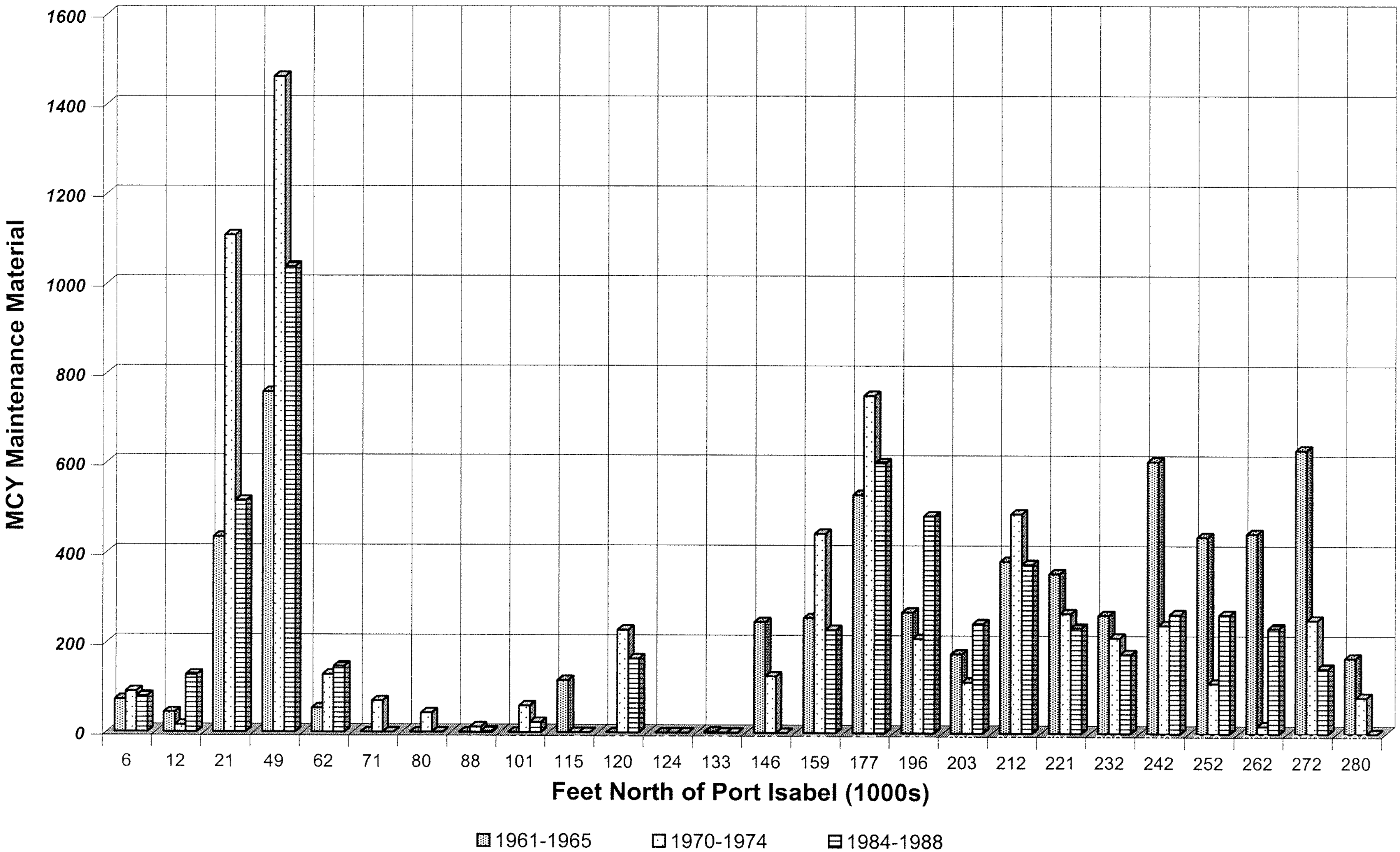

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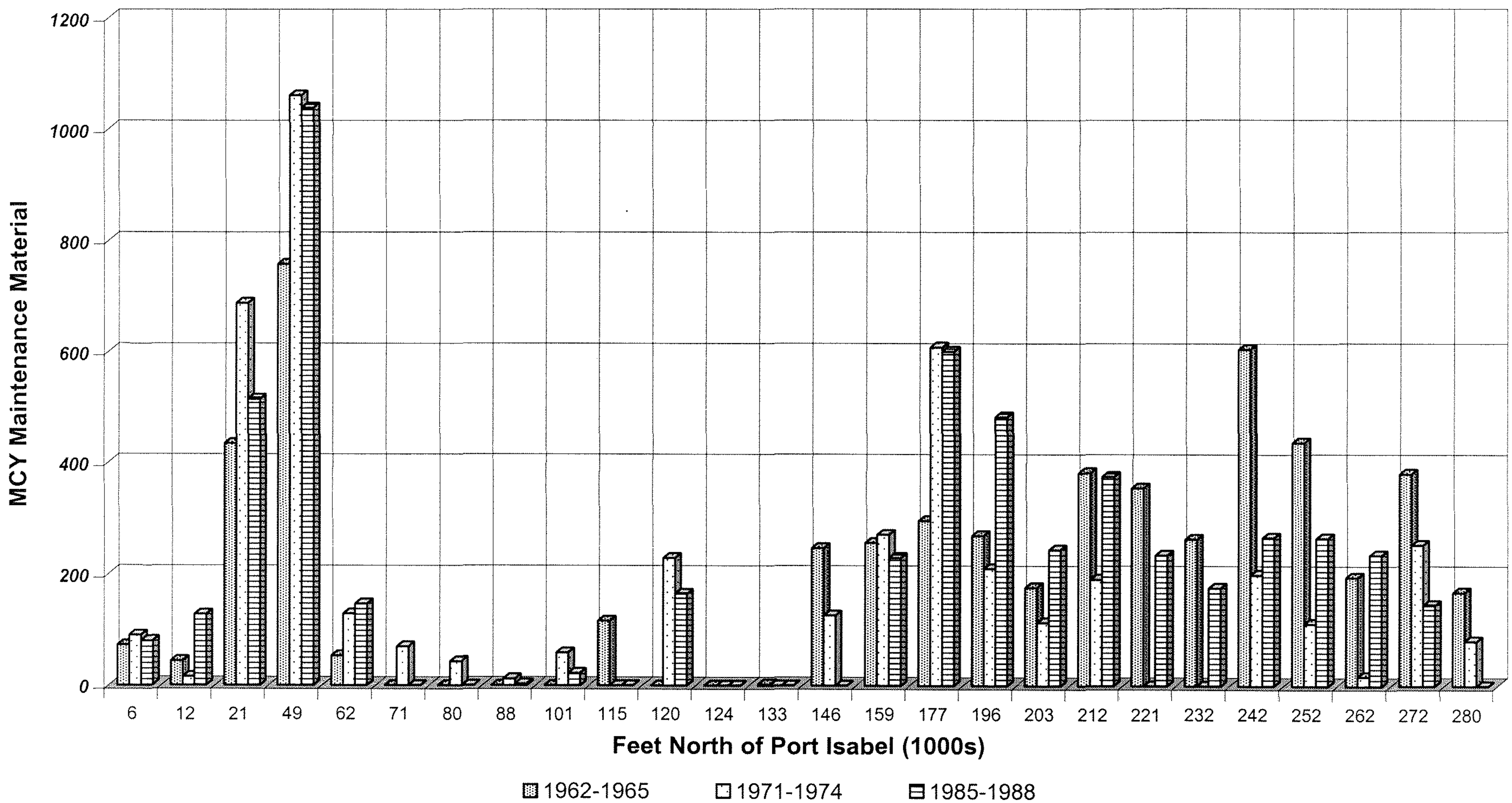
Figure 4-3
GIWW Maintenance Quantities - LLM (3-Year Period)



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0.8 mile from the placement site, even shortly after dredging and placement began. Turbidity in the water column is also discussed in Section 4.2.3.

In his 1996 study, Onuf (1996b) reports no changes to seagrass distribution between the 1988 to 1992 surveys, despite the reduction of underwater irradiation due to brown tide bloom from 1990–1995. He also recorded that >50 percent of the light reduction caused by the brown tide bloom did not have a discernible effect on seagrass distribution until after the fourth growing season, yet biomass changes were observed after two growing seasons, and he suggested that the lack of sampling sensitivity might have contributed to the difference in time periods seen in coverage decline and biomass decline. Aside from the sampling program characteristics, Onuf (1996a) mentions the possibility that surviving shoots use resources available to adjacent shoots that are dying from light reduction, thus, giving the appearance of persistence in the distribution coverage. Onuf reported the minimum surface irradiation (SI) or light level reaching the seagrass canopy level to maintain shoalgrass meadow coverage as approximately 15 percent while Dunton's (1994) study indicated approximately 18 percent SI as minimum requirement of shoalgrass. At a water depth of 1 meter, 18 percent SI is equivalent to a diffuse attenuation coefficient of 1.7, which is attained at a TSS concentration of approximately 25 mg/L (Burd, 2003a). Burd (2003b) notes that this means that at least 18 percent SI or 25 mg/L TSS is the average requirement during the plant's growing season (spring and summer months) even though instantaneous or even short-term values can be significantly different.

According to Dunton (2003), light penetration throughout the water column is regulated by concentrations of total suspended solids (TSS) and chlorophyll. The 18-month in situ study indicated that light reduction in the Laguna Madre was highest during periods of the highest chlorophyll concentrations (summer and fall), indicating the inordinate contribution of the persistent brown tide blooms. For both the ULM and the LLM, the greatest light attenuation was found at the non-vegetated LLM1, which is in an area of consistent high currents and turbidity from dredged material resuspension (Dunton, 2003). Dunton (1994) attributed losses of seagrass from deeper portions of the ULM to light attenuation from brown tide. In the LLM, chlorophyll concentrations peaked in late winter (March and April) from the advection of the brown tide bloom into the LLM during the winter by northers. Dunton (2003) suggests that the short-term winter appearance of the brown tide did not affect the seagrasses significantly in the LLM, since the lower water temperatures have already slowed down the photosynthetic and respiratory functions. Dunton (1994) showed seasonal changes in density and biomass of turtlegrass, shoalgrass, and manateegrass with ratios of above-ground to below-ground biomass highest in summer and lowest in winter. The results indicated no pronounced negative responses of density and biomass relative to the chlorophyll in the water column. Rapid recovery was observed in plant biomass after the brown tide disappeared (Burd, 2003b).

According to Burd (2003b), based on seagrass models in the Laguna Madre, shoalgrass and turtlegrass can withstand 2 weeks with very low light conditions, but 100 days of the light attenuation can result in decreases in both above-ground and below-ground plant biomass to less than the plant had at the beginning of the year for shoalgrass and roughly the same as at the beginning of the year for turtlegrass. Modeling simulations by Eldridge, Kaldy, and Maffione (2003) show that as the underwater irradiance level decreases, photosynthetic processes decrease, reducing the oxygen exchange to the root system. The decreased oxygen level slows the conversion of metabolites (sulfides) to non-toxic oxidized forms (sulfates, which are more tolerant to plants), an essential conversion for maintaining healthy, non-toxic sulfide levels (Eldridge and Morse, 1998). Morse (2003) found that sulfides rarely reached toxic levels, and Pulich (1989) states that toxic sulfide concentrations to seagrasses occur at >200 micromoles, though higher levels may be tolerated for short periods. Morse (2003) also found that high dissolved sulfides in sediments were primarily restricted to bare areas.

Aside from sulfides, toxic concentrations of other nutrients in the sediment can also affect seagrass health. Morin and Morse (2003) found that sediments in the bottom of the GIWW have large concentrations of ammonium associated with the sediment porewaters and solid fractions. Although ammonium is an essential source of nitrogen derived from seagrass detritus (Eldridge and Morse, 1998), Morin and Morse (2003) determined that resuspension of these sediments could result in possibly environmentally significant quantities of ammonium in the water column, particularly in shallow depths. They suggested that the potential alterations in ammonium concentrations, particularly the ratio of available NH_4^+ to available NO_3, could influence growth of planktonic algal communities in the Laguna Madre. DeYoe and Suttle (1994) have indicated that the Laguna Madre brown tide species cannot use nitrate as its N source. This brown tide species has likely adapted to take up NH_4^+ as its N source. Thus, the combination of low light conditions and high NH_4^+ resulting from dredging events could provide favorable conditions for proliferation of the brown tide in localized areas (Morin and Morse, 2003). However, it should be noted that no link between maintenance dredging and brown tide distribution has been determined. Also since maintenance dredging began in 1950, a brown tide event did not occur until January 1990 following an extreme cold weather event and a subsequent fish/benthos kill in 1989, as noted in Section 3.2.4.

According to Dunton (2003), in some areas of the LLM, such as near the mouth of the Arroyo Colorado, ammonium from agricultural runoff or municipal effluent may have affected levels of ammonium concentration in the water column. Nutrient input from point and non-point source discharges can feed phytoplankton blooms or macroalgal growth, and dredging and boating activities along with water currents and wave action can add to these effects by resuspending sediments (Morin and Morse, 1998).

In the Abstract of the results section of Dunton et al. (2003), Burd (2003a) states "Using the results of the WES models, the Seagrass model predicts that, at the sites modeled, the seagrasses survive the impacts of disposal of dredge material. The results also indicate that seagrass beds close to actual disposal sites will be impacted to a greater extent than those further away (as was seen in the results of the Verification Phase of this project)."

4.4.1.2 Recovery

Burd (2003a) describes two extended simulations, using data from the Verification Experiment from PA 235 (Burd and Eldridge, 2003) to determine whether turtlegrass can be expected to recover between dredging events. In the Verification Study, seagrasses were buried under 3.5 and 14 inches of dredged material at the first two sites chosen for monitoring, so the stations had to be moved a few hundred meters further from PA 235. The Verification Experiment, using data collected near an active PA in 1998, allowed the Thalassia model to be run at the control site (FIX 2, which was unaffected by dredging); at Site 235-ab, where seagrasses were buried; and at Site 235-cd, near PA 235, where seagrasses were impacted but not buried. The process of validation allowed the model to be modified such that it was able to predict the outcome of the dredging event on the seagrass and rhizosphere when provided with light data, thickness of deposition layer, and composition of dredged material.

The two extended simulations both modeled turtlegrass for 3 years, with the difference between them being that the first used a single dredging event at the beginning of the simulation and the other used dredging events in the first and third years. Only the turtlegrass model was used for these simulations that included a 2.75-inch burial by placement material. The study showed that although above-ground biomass increased by the third year, the decreased irradiance caused by sediment resuspension from the second dredging event led to an increase in sediment sulfide and ammonium concentrations, thus reversing the recovery of plants. Results indicated that alternating years of placement material did not provide sufficient time for plants to recover, leading to the death of the turtlegrass. Thus, as maintenance dredging and placement occurs at some sites as frequently as every other year, recovery of seagrass buried by the dredged material in these areas would not be possible. By 3 years after placement, seagrass had recovered to approximately 50 percent of above-ground biomass value prior to the material placement. The results of their simulations agreed with long-term field observations at site 235-cd, except that actual recovery of the turtlegrass was greater than predicted by the model. Eldridge and Kaldy (2003) extended the simulation to the fourth year, which revealed that approximately 75 percent of the pre-placement seagrass coverage would revegetate by that period; but as noted by Burd (2003a), the extended simulations basically just use the end point of the first year as the beginning point of the second year but use the light, wind, etc. data from the first year to drive the model, and the longer the simulation, the less confidence can be placed in the results. However, since these were the best data available, the ICT used this information to recommend the 4–5 year separation of dredging events, where applicable, in the DMMP, even though studies by Pete Sheridan (1998, 1999) have shown that colonization, which is not included in the modeling, would greatly increase the rate of recovery.

The authors stressed that the interpretation of this modeling effort was based on several assumptions, with these assumptions affecting the conclusions. Because the model was run without input from hydrodynamic or sediment transport modeling, effects of erosion, resuspension and deposition of dredged material, and the variety of currents could not be realistically incorporated into the model. The author states that in reality the sediment materials will be resuspended and deposited elsewhere, thus contributing to light reduction affecting photosynthetic activity but reducing the amount of burial. The lack of information about resuspension becomes more important as the time period of the simulation continues; and since the modeling is site specific, a different location would have differing water action and extent of sediment resuspension.

In another investigation conducted for this project, Sheridan (1999) studied how long changes in seagrass habitat and habitat use were detectible after dredged material placement and how far away from the disposal site such effects were observed. Three dredged material disposal sites (placement during 1995) in the ULM and LLM were included in the study. The study involved habitats at locations where deposits typically bury SAV, where SAV beds were located within 16.5 feet of placement of dredged material, and at undisturbed SAV beds approximately 0.6 mile from the disposal site.

Sheridan concluded that shallow submerged deposits could revegetate with seagrasses and attract mobile macro-fauna to levels comparable to pre-disposal conditions within approximately 5 years. However, because revegetation is site specific, some areas will not recover in that time period. At five sites in that study, 86 to 99 percent of the total area was revegetated after 3 years, while one site had revegetated to only 55 percent. He observed that SAV colonization at the Maximum Impact Areas was noticeable after 2 years, and significant vegetation coverage was observed after 3 years. Sheridan also found no consistent variations in temperature, salinity, or turbidity at 3.3–16.5 feet, 33–50 feet, 330–345 feet, and at least 3,300 feet from the edge of the fluid mound of mud, and stated turbidity seemed more a function of wind induced water action than from chronic, low-level erosion from the placement area.

The aforementioned studies provide analysis in describing factors associated with the growth and distribution of seagrass as a result of the direct and indirect impacts from maintenance dredged material placement. Through these studies it was determined that maintenance dredging activities in the Laguna Madre does have some adverse impacts on seagrass biomass and cover through burial and light attenuation. The spatial impacts, whether localized or large scale, from maintenance dredging induced turbidity are still the subject of much scientific debate at this time. In addition recovery of buried seagrasses in and around the placement areas may occur, however, if the burial is 3 inches or less, approximately 3 to 5 years is necessary without repeated dredged material placement, if the seagrass beds are to recover by seagrass growth through the sediments and flourish. However, Sheridan (1999) has shown that the area is more likely to recolonize from seed dispersal before the original plants can grow through the sediments. Although the chlorophyll concentration and brown tide affect are not directly linked to the effects of maintenance material placement, high concentrations of ammonium from dredged sediments could accentuate the brown tide bloom, which could ultimately impact recovery time.

Only placement on terrestrial upland areas or leveed containment areas would prevent direct impacts to the seagrass beds, though the conveyance to the upland sites would impact seagrass habitat, along with other estuarine and upland habitat. The terrestrial upland alternative has been explored and it has been determined to not be a workable option. However, based on the draft DMMP, negative impacts will be greatly lessened in comparison to the current No-Action alternative. Both direct and indirect impacts from the current practice of primarily open-bay disposal, will be ameliorated under the DMMP (preferred alternative), which will utilize a combination of confined, semiconfined and new open-water sites in unvegetated areas of the Laguna Madre as well as the historic open-water placement sites.

4.4.1.3 Comparison of Alternatives

The following table (Table 4-1) presents specific areas impacted both inside and outside the PA, both for the No-Action alternative and the DMMP alternative. The potential acreage of impacts were determined by the area that would be buried under the mud flow footprint, based on the information provided in Teeter et al. (2003). For each PA an attempt was made to determine whether the fluid mud

TABLE 4-1

SUMMARY OF IMPACTS FROM THE NO-ACTION AND THE DMMP ALTERNATIVES

PA	No-Action Alternative								DMMP Alternative							
	In PA				Out of PA				In PA				Out of PA			
	Upland	Seagrass	Open-Bay Bottom	Algal/Sand Flat	Upland	Seagrass	Open-Bay Bottom	Algal/Sand Flat	Upland	Seagrass	Open-Bay Bottom	Algal/Sand Flat	Upland	Seagrass	Open-Bay Bottom	Algal/Sand Flat
175	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
176	121.0	6.4	0.0	0.0	0.0	87.2	0.0	0.0	121.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0
177	28.9	1.6	1.6	0.0	20.9	40.2	13.4	0.0	28.9	1.6	1.6	0.0	0.0	0.0	0.0	0.0
178	95.5	23.9	0.0	0.0	0.0	59.9	0.0	0.0	102.9	44.1	0.0	0.0	0.0	48.5	0.0	0.0
179	33.7	5.9	0.0	0.0	0.0	21.0	0.0	0.0	61.1	15.3	0.0	0.0	0.0	10.5	0.0	0.0
180	95.1	31.7	0.0	0.0	0.0	81.3	0.0	0.0	120.5	31.7	0.0	0.0	0.0	40.6	0.0	0.0
180A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	98.6	0.0	0.0	0.0	102.7	0.0	0.0
181	58.5	39.0	0.0	0.0	0.0	40.0	0.0	0.0	58.5	39.0	0.0	0.0	0.0	20.0	0.0	0.0
182	50.7	9.0	0.0	0.0	0.0	45.2	0.0	0.0	57.9	14.5	0.0	0.0	0.0	22.6	0.0	0.0
182S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.8	11.7	0.0	0.0	0.0	50.2	0.0	0.0
183	67.7	67.7	0.0	0.0	0.0	68.4	0.0	0.0	67.7	67.7	0.0	0.0	0.0	34.2	0.0	0.0
184	59.2	39.5	0.0	0.0	2.6	49.7	0.0	0.0	59.2	39.5	0.0	0.0	1.3	24.9	0.0	0.0
185	45.9	45.9	0.0	0.0	3.9	74.3	0.0	0.0	61.3	44.4	0.0	0.0	2.0	37.2	0.0	0.0
186	5.2	87.8	10.3	0.0	0.0	11.7	85.8	0.0	6.4	133.6	72.1	0.0	0.0	0.0	97.5	0.0
187	12.9	115.7	0.0	0.0	0.0	135.0	15.0	0.0	12.9	115.7	0.0	0.0	0.0	67.5	7.5	0.0
188	7.1	135.2	0.0	0.0	0.0	157.7	0.0	0.0	7.1	135.2	0.0	0.0	0.0	78.9	0.0	0.0
189	8.6	99.3	0.0	0.0	0.0	130.3	0.0	0.0	8.1	153.8	0.0	0.0	0.0	32.6	32.6	0.0
190	3.3	63.0	0.0	0.0	0.0	102.0	0.0	0.0	3.3	63.0	0.0	0.0	0.0	51.0	0.0	0.0
191	9.6	54.6	0.0	0.0	0.0	7.3	74.1	0.0	45.0	19.3	0.0	0.0	0.0	12.2	28.5	0.0
192	0.0	74.2	13.1	0.0	0.0	2.6	50.2	0.0	8.7	65.4	13.1	0.0	0.0	1.3	25.1	0.0
193	18.0	72.1	0.0	0.0	0.0	38.8	14.3	0.0	59.9	64.8	0.0	0.0	0.0	25.2	1.3	0.0
194	10.1	30.3	60.6	0.0	0.0	18.1	42.1	0.0	18.2	20.2	62.6	0.0	0.0	0.0	0.0	0.0
195	0.0	59.7	0.0	32.1	0.0	4.4	0.0	83.3	16.5	67.8	11.0	87.9	0.0	43.8	0.0	0.0
196	75.3	18.8	0.0	0.0	3.8	49.0	22.6	0.0	103.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
197	113.1	110.1	74.4	0.0	0.0	120.1	98.2	0.0	107.5	153.5	46.1	0.0	0.0	91.7	17.5	0.0
198	6.7	20.0	106.5	0.0	15.2	14.3	60.1	0.0	13.3	13.3	106.5	0.0	0.0	13.5	76.2	0.0
199	10.8	41.0	56.1	0.0	0.0	16.7	94.8	0.0	18.4	43.6	105.6	0.0	0.0	4.5	107.0	0.0
200	38.1	0.0	152.4	0.0	0.0	0.0	88.0	0.0	38.1	0.0	152.4	0.0	0.0	0.0	88.0	0.0
201	34.4	0.0	137.7	0.0	0.0	0.0	120.5	0.0	34.4	0.0	137.7	0.0	0.0	0.0	142.0	0.0
202	155.5	0.0	27.4	0.0	0.0	33.1	33.1	0.0	254.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
203	321.7	0.0	0.0	0.0	10.9	344.9	0.0	7.3	335.9	0.0	0.0	0.0	109.8	13.6	0.0	0.0
204	163.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	193.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
206	405.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	515.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
207	309.2	0.0	0.0	0.0	231.8	0.0	0.0	0.0	309.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
208	951.2	0.0	0.0	0.0	714.3	0.0	0.0	0.0	951.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
209	192.8	0.0	0.0	0.0	144.6	0.0	0.0	0.0	192.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
210	215.9	0.0	0.0	0.0	129.1	0.0	0.0	0.0	259.5	0.0	0.0	0.0	129.1	0.0	0.0	0.0
211	29.5	44.2	0.0	0.0	32.0	181.5	0.0	0.0	93.4	89.7	0.0	0.0	0.0	38.0	0.0	0.0
212	57.9	77.1	57.9	0.0	0.0	53.3	55.5	0.0	57.9	77.1	57.9	0.0	31.0	23.4	0.0	0.0

TABLE 4-1 (Concluded)

PA	No-Action Alternative								DMMP Alternative							
	In PA				Out of PA				In PA				Out of PA			
	Upland	Seagrass	Open-Bay Bottom	Algal/Sand Flat	Upland	Seagrass	Open-Bay Bottom	Algal/Sand Flat	Upland	Seagrass	Open-Bay Bottom	Algal/Sand Flat	Upland	Seagrass	Open-Bay Bottom	Algal/Sand Flat
213	9.6	67.5	115.7	0.0	0.0	0.0	24.8	0.0	0.0	0.0	192.8	0.0	0.0	0.0	24.8	0.0
214	9.5	19.0	161.1	0.0	0.0	0.0	155.8	0.0	0.0	0.0	189.5	0.0	0.0	0.0	155.8	0.0
215	0.0	0.0	192.8	0.0	0.0	0.0	128.3	0.0	0.0	0.0	192.8	0.0	0.0	0.0	128.3	0.0
216	0.0	0.0	192.2	0.0	0.0	0.0	79.0	0.0	0.0	0.0	192.2	0.0	0.0	0.0	79.0	0.0
217	0.0	0.0	195.7	0.0	0.0	0.0	115.1	0.0	0.0	0.0	195.7	0.0	0.0	0.0	115.1	0.0
218	0.0	0.0	192.8	0.0	0.0	0.0	156.8	0.0	0.0	0.0	192.8	0.0	0.0	0.0	156.8	0.0
219	0.0	0.0	118.4	0.0	0.0	0.0	74.2	0.0	0.0	0.0	118.4	0.0	0.0	0.0	74.2	0.0
220	5.9	17.7	123.6	0.0	0.0	2.6	128.2	0.0	7.6	17.7	151.4	0.0	69.0	0.0	0.0	0.0
221	10.5	39.3	212.0	0.0	0.0	10.8	61.3	0.0	0.0	20.3	233.6	0.0	0.0	24.2	46.9	0.0
222	140.4	32.0	5.3	0.0	21.9	99.7	0.0	0.0	223.6	55.9	0.0	0.0	0.0	0.0	0.0	0.0
223	129.5	6.8	0.0	0.0	2.7	35.6	0.0	0.0	145.3	59.3	0.0	0.0	0.0	0.0	0.0	0.0
224	145.6	9.3	0.0	0.0	0.0	0.0	0.0	0.0	217.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
225	49.6	0.0	0.0	0.0	58.0	0.0	0.0	14.5	81.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
226	251.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	251.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
227	25.7	38.6	0.0	0.0	22.2	51.8	0.0	0.0	25.7	38.6	0.0	0.0	0.0	0.0	0.0	0.0
228	146.7	146.7	0.0	0.0	0.0	0.0	0.0	0.0	356.5	62.9	0.0	0.0	0.0	0.0	0.0	0.0
229	57.9	70.7	0.0	0.0	0.0	0.0	0.0	0.0	57.9	70.7	0.0	0.0	0.0	0.0	0.0	0.0
230	49.5	33.0	0.0	0.0	2.3	8.1	0.0	0.0	49.5	33.0	0.0	0.0	1.1	4.1	0.0	0.0
231	57.1	69.8	0.0	0.0	2.1	16.6	0.0	0.0	57.1	69.8	0.0	0.0	1.0	8.3	0.0	0.0
232	35.5	91.4	0.0	0.0	0.0	0.0	0.0	0.0	48.0	151.9	0.0	0.0	0.0	0.0	0.0	0.0
233	0.0	44.0	165.5	0.0	0.0	13.7	329.7	0.0	0.0	0.0	209.5	0.0	0.0	0.0	343.4	0.0
234	0.0	133.9	57.4	0.0	9.9	82.6	72.7	0.0	0.0	0.0	191.2	0.0	0.0	0.0	165.2	0.0
235	0.0	127.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	191.6	0.0	0.0	0.0	0.0	0.0	0.0
236	0.0	95.5	10.6	0.0	0.0	0.0	0.0	0.0	0.0	95.5	10.6	0.0	0.0	0.0	0.0	0.0
239	0.0	0.0	49.0	0.0	0.0	0.0	88.3	0.0	0.0	0.0	49.0	0.0	0.0	0.0	88.3	0.0
240	31.0	0.0	0.0	0.0	6.4	9.6	0.0	0.0	31.0	0.0	0.0	0.0	3.2	4.8	0.0	0.0
Subtotals	5,000.3	2,415.8	2,490.2	32.1	1,434.7	2,319.3	2,281.9	105.1	5,990.5	2,497.8	2,886.1	87.9	347.7	929.9	2,001.1	0.0
Totals for both Inside and Outside of the PAs.					6,435.0	4,735.1	4,772.1	137.2					6,338.2	3,427.7	4,887.2	87.9

footprint could be retained inside the PA. If not, the additional width required to contain the footprint was determined. Both determinations were made from the formula $V = 0.04166L^2$, provided by Allen Teeter at WES, where L is the diameter of the footprint and was set equal to the width of each PA. The factor, 0.04166 (comprising the limited sediment loading and the in-channel dry density), is based on data collected from the Laguna Madre. The factor also agrees with data collected from the dredging operation sampled by Mr. Teeter and PBS&J near PA 216 and data collected by CBI near PA 233. The seagrass map prepared by Dr. Chris Onuf from his survey of the lagoon in 1998, conducted for a Status and Trends report for the Gulf of Mexico Program, was overlaid on the 1996 DOQQs and the GIWW and PA locations. The seagrass map was used (except for a very limited area where more recent information relative to coverage was available) to identify the percentage of seagrass versus bare bottom areas. Also included in the calculations were the percentages of upland and sand/algal flat areas in the PA and a 1,500-foot swath on the non-GIWW side of the PA, since it has been determined by WES and from the Houston-Galveston Navigation Project that 1,500 feet is about the maximum distance that burial can be expected for the mudflow from a single placement event. As discussed in the water column impacts section, the ICT also examined the plume of turbidity and its impact on seagrass. But since the impact of turbidity is less clear than burial, and since the models showed that all seagrasses survived if they were somewhat removed from the placement, direct burial was used for the comparison of alternatives. Table 4-1 also presents the total impact acreage to the four habitats for the No-Action alternative and the DMMP alternative.

Table 4-2 presents the difference in impact acreage for the four habitats between the No-Action alternative and the DMMP alternative, both for each PA and the total alternative. These numbers are derived by subtracting the No-Action alternative acreage from the DMMP alternative acreage. A negative number indicates fewer acres of impact from the DMMP alternative.

For the areas inside the PAs, there is an increase in impacts to seagrass (roughly 82 acres) by the DMMP alternative relative to the No-Action alternative, because some PAs were expanded to provide sufficient capacity or levees were built out into area where seagrasses were found. However, when the out-of-PAs areas are examined, around 1,307 fewer acres of seagrasses are expected to be impacted by the DMMP alternative, even though more seagrasses would be impacted at 180A, which may not be used or may be used only on a limited basis. These numbers cannot be considered absolute since 1) for purposes of calculation a complete historical average per-cycle quantity of dredged material was used for each PA, when the quantity may be split among different PAs; and 2) the formula provided by Mr. Teeter is for the average maintenance material in the Laguna Madre GIWW, so the calculations will not be totally accurate for each PA or for each dredging cycle. However, it does provide a strong indication that the DMMP should be much less harmful to seagrasses by burial alone. Decreased turbidity, which should also occur, could provide additional benefits.

4.4.1.4 Expanded and New PAs

Table 4-3 provides a brief description of the changes made at each new PA or PA that is being expanded, and the changes in area that the creation or expansion had on four types of habitat: upland; seagrass; open-bay bottom, including channels; and algal or sand flats. A positive number in the

TABLE 4-2

DIFFERENCES BETWEEN THE NO-ACTION AND THE DMMP ALTERNATIVES

PA	In PA				Out of PA				Brief DMMP Summary
	Upland	Seagrass	Open-Bay Bottom	Algal/Sand Flat	Upland	Seagrass	Open-Bay Bottom	Algal/Sand Flat	
175	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Upland PA
176	0.0	0.0	0.0	0.0	0.0	-87.2	0.0	0.0	Go to UCPA
177	0.0	0.0	0.0	0.0	-20.9	-40.2	-13.4	0.0	Increase in levees, pump onto islands
178	7.4	20.2	0.0	0.0	0.0	-11.4	0.0	0.0	Expand, increase in levees, pump onto islands
179	27.4	9.3	0.0	0.0	0.0	-10.5	0.0	0.0	Expand, pump onto islands
180	25.4	0.0	0.0	0.0	0.0	-40.6	0.0	0.0	Pump onto islands/diffuser
180A	5.2	98.6	0.0	0.0	0.0	102.7	0.0	0.0	New PA for bird use
181	0.0	0.0	0.0	0.0	0.0	-20.0	0.0	0.0	Pump onto islands/direct flow
182	7.1	5.5	0.0	0.0	0.0	-22.6	0.0	0.0	Pump onto islands/diffuser
182S	21.8	11.7	0.0	0.0	0.0	50.2	0.0	0.0	New PA
183	0.0	0.0	0.0	0.0	0.0	-34.2	0.0	0.0	Pump onto islands/direct flow
184	0.0	0.0	0.0	0.0	-1.3	-24.9	0.0	0.0	Pump onto islands/direct flow
185	15.3	-1.6	0.0	0.0	-2.0	-37.2	0.0	0.0	Pump onto islands/direct flow
186	1.2	45.8	61.8	0.0	0.0	-11.7	11.7	0.0	Expand, pump into deeper water
187	0.0	0.0	0.0	0.0	0.0	-67.5	-7.5	0.0	Pump onto islands/direct flow
188	0.0	0.0	0.0	0.0	0.0	-78.9	0.0	0.0	Pump onto islands/direct flow
189	-0.5	54.6	0.0	0.0	0.0	-97.7	32.6	0.0	Expand, increase levees, pump onto islands
190	0.0	0.0	0.0	0.0	0.0	-51.0	0.0	0.0	Pump onto islands/direct flow
191	35.4	-35.4	0.0	0.0	0.0	4.9	-45.6	0.0	Increase levees, pump onto islands
192	8.7	-8.7	0.0	0.0	0.0	-1.3	-25.1	0.0	Pump onto islands/direct flow
193	41.8	-7.2	0.0	0.0	0.0	-13.5	-13.0	0.0	Expand, pump onto islands
194	8.1	-10.1	2.0	0.0	0.0	-18.1	-42.1	0.0	Increase levees, pump onto islands
195	16.5	8.1	11.0	55.8	0.0	39.5	0.0	-83.3	Expand, pump onto islands
196	28.0	-18.8	0.0	0.0	-3.8	-49.0	-22.6	0.0	Expand, increase levees, pump onto islands
197	-5.6	43.4	-28.3	0.0	0.0	-28.4	-80.8	0.0	Expand, pump onto islands
198	6.7	-6.7	0.0	0.0	-15.2	-0.9	16.1	0.0	Continue into unvegetated area
199	7.7	2.6	49.5	0.0	0.0	-12.3	12.3	0.0	Expand, pump onto deeper water
200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Continue into unvegetated area
201	0.0	0.0	0.0	0.0	0.0	0.0	21.5	0.0	Continue into unvegetated area
202	98.9	0.0	-27.4	0.0	0.0	-33.1	-33.1	0.0	Go to UCPA
203	14.2	0.0	0.0	0.0	98.9	-331.3	0.0	-7.3	Expand, increase use of UCPA
204	30.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Expand, continue use of UCPA
206	109.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Continue use of upland PA
207	0.0	0.0	0.0	0.0	-231.8	0.0	0.0	0.0	Continue use of upland PA
208	0.0	0.0	0.0	0.0	-714.3	0.0	0.0	0.0	Continue use of upland PA
209	0.0	0.0	0.0	0.0	-144.6	0.0	0.0	0.0	Continue use of upland PA
210	43.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Continue use of upland PA
211	63.9	45.5	0.0	0.0	-32.0	-143.5	0.0	0.0	Expand, increase levees, pump onto islands
212	0.0	0.0	0.0	0.0	31.0	-29.9	-55.5	0.0	Pump onto islands/direct flow
213	-9.6	-67.5	77.1	0.0	0.0	0.0	0.0	0.0	Continue into unvegetated area
214	-9.5	-19.0	28.4	0.0	0.0	0.0	0.0	0.0	Continue into unvegetated area
215	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Continue into unvegetated area
216	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Continue into unvegetated area
217	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Continue into unvegetated area
218	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Continue into unvegetated area
219	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Continue into unvegetated area
220	1.8	0.0	27.8	0.0	69.0	-2.6	-128.2	0.0	Expand. increase levees, pump onto islands
221	-10.5	-18.9	21.6	0.0	0.0	13.4	-14.4	0.0	Create New PA in deeper water
222	83.2	23.9	-5.3	0.0	-21.9	-99.7	0.0	0.0	Expand, go to UCPA
223	15.7	52.5	0.0	0.0	-2.7	-35.6	0.0	0.0	Expand, go to UCPA
224	72.2	-9.3	0.0	0.0	0.0	0.0	0.0	0.0	Expand, go to UCPA
225	31.6	0.0	0.0	0.0	-58.0	0.0	0.0	-14.5	Go to UCPA
226	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Continue use of UCPA
227	0.0	0.0	0.0	0.0	-22.2	-51.8	0.0	0.0	Pump onto islands/direct flow
228	209.7	-83.8	0.0	0.0	0.0	0.0	0.0	0.0	Expand, go to UCPA
229	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pump onto islands/direct flow
230	0.0	0.0	0.0	0.0	-1.1	-4.1	0.0	0.0	Use as at present with seasonal restrictions
231	0.0	0.0	0.0	0.0	-1.0	-8.3	0.0	0.0	Use as at present with seasonal restrictions
232	12.4	60.5	0.0	0.0	0.0	0.0	0.0	0.0	Pump onto islands/diffuser
233	0.0	-44.0	44.0	0.0	0.0	-13.7	13.7	0.0	Create New PA in deeper water
234	0.0	-133.9	133.9	0.0	-9.9	-82.6	92.5	0.0	Create New PA in deeper water
235	8.0	64.7	0.0	0.0	0.0	0.0	0.0	0.0	Use as at present with seasonal restrictions
236	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Use as at present with seasonal restrictions
239	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Continue present practice
240	0.0	0.0	0.0	0.0	-3.2	-4.8	0.0	0.0	Continue present practice in semi-UCPA
Subtotals	1023.5	82.0	396.0	55.8	-1087.0	-1389.5	-280.9	-105.1	
Totals for both Inside and Outside of the PAs.					-63.5	-1307.46	115.1	-49.3	

TABLE 4-3

CHANGES IN PLACEMENT AREA BOUNDARIES IN THE LAGUNA MADRE

PA	Changes Made	Upland (ac)	Seagrass (ac)	Bay Bottom (ac)	Algal/Sand Flat (ac)
178	Move the boundary south.	7.4	20.2	0.0	0.0
179	Move the boundary south.	27.4	9.3	0.0	0.0
180A	New PA, west of GIWW.	5.2	98.6	0.0	0.0
182	Move the boundary south.	7.1	5.5	0.0	0.0
182S	New PA between PAs 182 and 183.	21.8	11.7	0.0	0.0
184	No change in the boundaries, but the DMMP has option to pipe excess dredged material over to Emmond's Hole; about 2.5 miles.	0.0	0.0	0.0	0.0
185	Move the boundary south.	15.3	-1.6	0.0	0.0
186	Move the boundary west about 1,000 feet to include deep water in Emmord's Hole.	1.2	45.8	61.8	0.0
189	Move boundary west about 1,000 feet at the north end and taper boundary back to connect to present southwest corner.	-0.5	54.6	0.0	0.0
193	Move the north, west, and south boundaries out to include all islands.	41.8	-7.2	0.0	0.0
195	Move boundary south and east.	16.5	8.1	11.0	55.8
196	Move boundary north and south.	28.0	-18.8	0.0	0.0
197	Move boundary east about 500 feet from the north end of the southernmost island and back in at the south end of the southernmost island.	-5.6	43.4	-28.3	0.0
199	Move boundary south to connect with PA 200.	7.7	2.6	49.5	0.0
202	Move boundary south to the channel between PAs 202 and 203. Move boundary west to include the levee.	98.9	0.0	-27.4	0.0
203	Move boundary west to include the levee.	14.2	0.0	0.0	0.0
204	Move boundary west to include the levee.	30.4	0.0	0.0	0.0
206	Move boundary west to include the levee.	109.9	0.0	0.0	0.0
211	Move boundaries north and east.	63.9	45.5	0.0	0.0
220	Move the outside boundary out to include all of the island in the bend of the PA.	1.8	0.0	27.8	0.0
221	Designate new site for PA 221 (PA 221A) on east side of GIWW.	-10.5	-18.9	21.6	0.0
222	Move boundary west.	83.2	23.9	-5.3	0.0
223	Move boundary west.	15.7	52.5	0.0	0.0
224/ 225	Extend the south boundary of PA 224 and north boundary of PA 225 to connect to each other. Move boundaries of both PAs east.	72.2	-9.3	0.0	0.0
		31.6	0.0	0.0	0.0
228	Move boundary west.	209.7	-83.8	0.0	0.0
232	Move boundaries south and west.	12.4	60.5	0.0	0.0

TABLE 4-3 (Concluded)

PA	Changes Made	Upland (ac)	Seagrass (ac)	Bay Bottom (ac)	Algal/Sand Flat (ac)
233/ 234	Create a new PA (PA 233A) in the deep water to the south and west of these PAs. The pipeline distance measured from the GIWW to PA 233A across the original PA 233 is about 2 miles to the southwest. The distance across PA 235 is about 1 mile to the west.	0.0	-44.0	44.0	0.0
		0.0	-133.9	133.9	0.0
235	Move the west boundary out to enclosure all of the islands outside of the PA.	8.0	64.7	0.0	0.0
Totals		914.8	229.3	288.4	55.8

table indicates that the DMMP alternative impacts more of a receptor than does present practice and, therefore, an increase in the acres impacted. Emmord's Hole is covered under PA 184, but since the area of impact does not include seagrasses, and thus, the reason for its consideration by the ICT, it is not included here, but is addressed in Sections 2.11.7 and 4.4.4. Twenty-three of the changes will have either decreased (8) or increased (15) impacts on seagrass, relative to the No-Action alternative. Fewer acres will be directly impacted at PAs 185, 193, 196, 221, 224, 228, 233, and 234. More acres of seagrass will be directly impacted at PAs 178, 179, 180A, 182, 182S, 186, 189, 195, 197, 199, 211, 222, 223, 232, and 235. Together, the changes in acres of seagrass impacted sum to 229.3 more acres impacted by expansion and creation of PAs, relative to the 180,000 acres in the Laguna Madre (Onuf 1996b). However, as noted above, it was assumed, for instance that all material would go to PA 180A, a very unlikely scenario since the amount of material dredged near PA 180 per cycle is much more than that needed to increase the size of the two small bird islands and, thus, much of the material will go to PA 180, rather than 180A. Since 180A accounts for 98.6 acres of impact, this could have a dramatic effect on the net change of seagrass impacted from the expansion/construction of PAs. Of course, as noted above, the overall change for inside and outside all PAs with the DMMP alternative is 1,307 fewer acres of seagrass impacted.

4.4.2 Coastal Wetlands

For both the No-Action alternative and the DMMP alternative some wetlands, both low and high salt marsh, will be impacted in the locations where placement will occur. There are minor fringes of high salt marsh (typically identified by saltwort and glasswort) around the emergent PAs as well as inside some PAs, thus, the potential exists that impacts will occur in these areas. After consolidation of disposal material, these areas will revegetate, unless replaced with a levee, since similar habitat will be available for revegetation after the placement material consolidates. Since the DMMP alternative relies more heavily on upland placement than does the No-Action alternative, to protect seagrasses and expand islands for shorebird use, more impacts to high salt marsh can be expected with the DMMP alternative. Since there are no definitive surveys of the Laguna Madre with respect to high and low salt marshes, this has not been quantified.

4.4.3 Tidal Flats (including Algal Flats)

The No-Action alternative will continue impacting tidal flat habitat with current disposal practices. Impacts to flats will occur in areas associated with the existing emergent disposal islands. This impact will likely be temporary, until the material consolidates. In total, 137 acres of tidal flats are expected to be impacted, both inside and outside of the PAs with the No-Action alternative.

The preferred alternative (DMMP) will also affect flats in areas associated with the existing disposal islands. Similar to the No-Action alternative, there will be burial of flats, though the effects from this burial may be temporary as new habitat will be created. In addition, permanent impacts may occur on flats where disposal material may bury the area and potentially elevate the area to a more upland habitat community. As noted in the DMMP, this was only of concern to the ICT at the expansion of PA 195, because of potential piping plover habitat. This PA will be examined more closely before placement occurs. The FWS visited the PA and noted that constituent elements for the piping plover existed there and some plovers were seen, but a resolution of this concern was not made. However, since the flow will be directed to the south, the dredged material placement should not impact the algal flats to the east of the existing or proposed PA 195, and Table 4-2 shows a decrease in impacts to flats because the flow to the east from the existing PA under present practices should impact some flats. The only other change to flats is an expected decrease at PA 225 where going to upland confined placement will prevent flow onto flats to the west of the PA.

An examination of Table 4-3 for impacts from expanded and new PAs shows that only the expansion of PA 195 will have impacts to algal/sand flats. This includes the areas around the upland areas in the northern potion of the extension, including the area north of the turning basin, and the large flat to the south of the old oil exploration canal. By use of these flats, and the canal itself, impacts to seagrasses would be greatly reduced. The maximum area impacted is 87.9 acres, 49.1 acres fewer than with the No-Action alternative. Given the huge areas of tidal flats ("hundreds of square miles" [Pulich et al., undated]), this is not considered a significant change.

4.4.4 Open-Water/Reef Habitat

No live oyster reefs occur within the Laguna Madre ecosystem, with the exception of the South Bay population. This oyster reef is roughly 2.5 miles away from PA 240. PA 240 is a semiconfined site which is infrequently used, and the effluent discharge is placed so it flows out into adjacent shallow flats. Therefore, adverse impacts to oyster resources are not expected to occur as a result of dredging and dredged material placement operations for the No-Action or DMMP alternative.

Remnants of two types of naturally occurring hard substrate formations occur near the project vicinity: serpulid reefs and coquina rock outcrops. Serpulid reefs are located in Baffin and Alazan bays. PAs 193 through 199 are located near the mouth of Baffin Bay. Coquina rock outcrops are located from Baffin Bay at Penascal Point and run for 6.2 miles south along the mainland shore. PAs 198 to 208 are located along this reach. Although these natural formations are not living, they still provide a valuable hard-structure resource within the bay ecosystem. Since upland placement is not proposed in the DMMP (preferred alternative) and would not occur with the No-Action alternative, no pipelines to the mainland would impact these resources. Maintenance dredging in the past has not impacted the resources so there is no reason to expect the DMMP alternative to impact them.

If necessary, an alternative placement site in Emmord's Hole, located west of PA sites 184–189, and discussed in detail in Section 2.11.7, is being considered. This depression is up to 3.3 feet deeper than the surrounding lagoon bottom, thus reaching approximately 6.6 feet below MLLW. According to Onuf (1996a) this area became unvegetated after the influence of brown tide during four growing seasons. The northern portion of Emmord's Hole is considered appropriate for placement and is located above latitude 27.47 degrees north, where the depression is separated from the GIWW by a shallow sill. The remainder of the feature is connected to or slopes toward the GIWW, where runback into the channel could be a problem (Teeter et al., 2003).

4.4.5 Coastal Shore Areas/Beaches/Sand Dunes

Since ocean placement, beach nourishment, and washover nourishment are not proposed via pipeline, no impacts to these communities are expected with the DMMP alternative, nor would they occur under the No-Action alternative. Should ocean placement occur for material from portions of the GIWW near the Port Mansfield Channel or the BIH, placement would be by hopper barges far enough offshore that impacts to these communities would not be expected. Additionally, requirements for ocean disposal under 40 CFR 220–228, which protects various receptors, including coastal shore areas and beaches, would have to be met.

The No-Action alternative will continue placement in existing PAs where shorelines around islands occur. Shorelines associated with these islands may be buried with maintenance material; however, erosion will allow the areas to be restored or the shoreline will merely move its relative position and become reestablished. This impact would be considered a short-term temporary affect. No negative impacts to sand dunes will occur. There could be disturbance to small beach areas on the PAs. Again, the specific amounts are not known, and the impacts could be permanent or temporary, depending on the location of the beaches and the amount of maintenance material placed.

The preferred alternative (DMMP) alternative action will also affect the PAs in the same manner as the No-Action alternative. Impacts to shorelines on the disposal islands will be short-term temporary affects, unless levees include these areas. No negative impacts to sand dunes will occur. There could be disturbance to small beach areas on the PAs. The specific amounts are not known, and the impacts could be permanent or temporary, depending on the location of beach areas on the PAs, the amount of maintenance material placed on the beach area, and levee construction. However, compared with the large area of coastal shore area and beaches in the project area, neither the impacts of the No-Action alternative nor the DMMP alternative can be considered significant.

4.4.6 Upland Grasslands

The No-Action alternative will continue the practice of placement on PAs that support grassland communities. Impacts to these areas may be permanent; long-term temporary; or short-term temporary depending on the depth of the maintenance material placed on the island and frequency of dredging cycles. The upland PAs without frequent maintenance material placement will revegetate. No mainland grassland areas will be impacted.

The DMMP alternative will also not impact any mainland grassland communities. As with the No-Action alternative, there will be impacts to grassland communities on islands inside PAs. Impacts to these areas may be permanent; long-term temporary; or short-term temporary for the same reasons. With infrequent maintenance disposal these areas will revegetate. However, compared with the large area of upland grasslands in the project area, neither the impacts of the No-Action alternative nor the DMMP alternative can be considered significant.

4.5 FINFISH AND SHELLFISH RESOURCES

Although water column turbidity would increase in open-bay habitats during dredging and placement activities, such effects are usually temporary and local. Several studies of turbidity from TSS associated with dredging operations have concluded that dredging had no substantial effects on nekton (Ritchie, 1970; Stickney, 1972; Wright, 1978); however, other studies have shown that elevated TSS levels and prolonged exposure can suffocate and reduce growth rates of adult and juvenile nekton and reduce viability of eggs (Moore, 1977; Stern and Stickle, 1978). Detrimental effects are generally recognized at TSS concentrations greater than 500 mg/L and for durations of continuous exposure ranging from several hours to a few days. Turbidities exceeding 500 mg/L have been observed around maintenance dredging and placement operations (EH&A, 1980), and such turbidities may affect some aquatic organisms near the active dredges and outflow weirs. In a study in Corpus Christi Bay, Schubal et al. (1978) reported TSS values greater than 300 mg/L but only in a relatively small area near the bottom. They also found that TSS from maintenance dredging in Corpus Christi Bay is not greater than that from shrimping and affects the bay for much shorter time periods. May (1973) found that TSS was reduced by 92 percent within 100 feet of the discharge point, by 98 percent at 200 feet, and that concentrations above 100 mg/L were seldom found beyond 400 feet from the point of placement. Elevated turbidities during construction and maintenance dredging may affect some aquatic organisms near the dredging activity; however, turbidities in open-bay habitats can be expected to return to near ambient conditions within a few hours after dredging ceases or moves out of a given area. Schidler (1984) reports similar TSS levels from dredging and storm events. Overall, motile organisms are mobile enough to avoid highly turbid areas (Hirsch et al., 1978). Under most conditions, fish and other motile organisms are only exposed to localized suspended-sediment plumes for short durations (minutes to hours) (Clarke and Wilber, 2000). See Section 4.2 for a discussion of plumes and turbidity. At placement areas where levees are proposed to be built, there would be one time water column turbidity increases during construction.

Finfish and shellfish communities are altered over time; however, there are indications that mobile organisms are able to respond quickly to dredged material placement. In Sheridan's 1998 study of the Lower Laguna Madre, fish densities at non-vegetated dredged material sites compared with nearby SAV beds did not differ significantly 1.5 to 3 years after placement occurred, whereas changes in community composition was distinctive. While shellfish species compositions were similar to those in natural SAV beds, densities were lower at the site of dredging. Conversely, no differences in nekton communities were observed between SAV-colonized placement areas and natural SAV beds. In Sheridan (1999), fish and shellfish communities from six placement areas in the ULM and LLM were examined after dredging placement occurred. It was found that total numbers of fish and shellfish increased as SAV coverage and above-ground biomass increased over time; however, 3 years after deposition, the subtidal, unvegetated dredged material placement areas had not recovered to the extent of nearby undisturbed SAV beds. Brown-Peterson et al. (1993) studied fish communities in natural SAV beds compared with post-placement colonized SAV beds over 30 years after dredging in Florida. Differences in fish species composition and SAV shoot densities were observed, although fish densities remained similar in most seasons. Brown-Peterson et al. (1993) concluded that restoration of SAV in an area does not guarantee the return of the fishery habitat value.

Notwithstanding the potential harm to some individual organisms, compared with the existing condition, no significant impacts to finfish or shellfish populations are anticipated from the maintenance dredging and placement operations for the No-Action alternative or the DMMP alternative. Should seagrass communities benefit from the DMMP alternative, finfish and shellfish would also benefit.

In the event a petroleum product spill should occur, however low the probability, adult crustaceans, such as shrimp and crabs, and adult finfish are probably mobile enough to avoid most areas of high oil concentrations. Larval and juvenile finfish and shellfish tend to be more susceptible to oil than adults and could be affected extensively by an oil spill during their active immigration periods. Due to their lack of mobility, they are less likely to be able to avoid these areas and could be negatively impacted if a spill were to occur. There is no difference in the likelihood of oil spills with the No-Action or DMMP alternatives, but some of the other options that were eliminated, such as hopper dredges going offshore and pipeline dredges using scows to transport the material offshore, would have increased the potential for collisions and, therefore, contaminant spills.

4.5.1 Recreational and Commercial Species

Temporary and minor adverse effects on recreational and commercial fisheries may result from altering or removing productive fishing grounds and interfering with fishing activity. Sheridan (1999) found that sheepshead, spotted seatrout, brown shrimp, pink shrimp, white shrimp, and blue crab numbers increased as SAV coverage improved following dredging, with few species collected at the site of the disturbance. Only spot, Atlantic croaker, and southern flounder were somewhat more numerous at the dredged material placement area. However, the evaluation of effects on the aquatic communities of the region (presented in Section 4.5.2) concluded that no significant impacts to food sources for nekton were likely. Therefore, reductions of nekton standing crops would not be expected from the No-Action or DMMP alternative. In particular, major species of nekton, including the sciaenid fishes and penaeid shrimp, should not suffer any significant losses in standing crop. Recreational and commercial fishing would, therefore, not be expected to suffer from reductions in the numbers of important species for the No-Action or DMMP alternative.

Repeated dredging and placement operations may temporarily reduce the quality of recreational and commercial fisheries in the vicinity of dredging operations. This may result from decreased water quality and increased turbidity during dredging as well as from a loss of attractiveness to game fish resulting from loss of benthic prey. Impacts would be greater in the ULM where most commercial fishing occurs. This condition is not permanent; however, the quality of fishing in the vicinity of the channel and the placement areas should steadily improve after dredging is completed and would likely be similar to existing maintenance dredging, as under the No-Action alternative. At PAs 184 through 188, there is the possibility under the DMMP alternative that Emmord's Hole, a prime recreational fishing spot in the ULM, would be used as a dredged material disposal site. During such time, game fish would leave the area for more favorable, less turbid locations. However, once dredging in this reach is completed, conditions would improve and game fish would return to the site.

The impacts from the No-Action and DMMP alternatives to both boat and wade-bank fishing would be temporary, potentially resulting in local disturbances, particularly along the edges of the channels and emergent dredged material placement areas. After maintenance dredging is completed, these areas should return to pre-dredging conditions. A significant portion of the overall recreational fishing effort in the general project area occurs in the Laguna Madre; however, dredging activities should not significantly affect overall fishing. In areas where emergent dredged material placement areas are located, the physical activity of dredging and placement and the resulting local turbidity increases would combine to temporarily decrease the success rate and aesthetics of fishing in these areas.

Commercial fishing for shellfish in the Laguna Madre is very limited, therefore no impacts are expected for the No-Action alternative or the DMMP alternative.

4.5.2 Aquatic Communities

Turbidity in estuarine and coastal waters is generally credited with having a complex set of impacts on a wide array of organisms (Thompson, 1973; Hirsch et al., 1978; Stern and Stickle, 1978; EH&A, 1978; Wright, 1978). Suspended material can play both beneficial and detrimental roles in aquatic environments. Turbidity from TSS tends to interfere with light penetration and thus reduce photosynthetic activity by phytoplankton. Such reductions in primary productivity would be localized around the immediate area of the maintenance dredging operations and would be limited to the duration of the plume at a given site. Conversely, this decrease in primary production, presumably from decreased available light, has been found to be offset by increased nutrient content (Morton, 1977). In past studies of the impacts from turbidity and nutrient release associated with dredged material placement, the effects are considered both localized and temporary (May, 1973; Odum and Wilson, 1962; Brannon et al., 1978). Therefore, due to the reproductive capacity and natural variation in phytoplankton populations, the impacts of dredged material placement within the project area are not expected to be significant for the No-Action alternative or the DMMP alternative. At placement areas where levees will be built, there would be one time water column turbidity increases during construction but long-term decreases.

Effects of elevated turbidities on the adult stages of various filter-feeding organisms such as oysters, copepods, and other species include depression of pumping and filtering rates and clogging of filtering mechanisms (Stern and Stickle, 1978). These effects are pronounced when TSS ranges from 100 to 1,000 mg/L and higher, but are apparently reversible once turbidities return to ambient levels. Since there would be fewer dredged material plumes with the DMMP alternative, any impacts from turbidity on filter-feeding organisms would be reduced.

Dredging represents two problems for benthic communities: excavation and disposal; however, disposal is more harmful than excavation. Excavation buries and removes organisms, but organisms can rapidly recolonize, whereas disposal smothers or buries existing benthic communities. Disposal of dredged material may cause ecological damage to benthic organisms in three ways: 1) physical disturbance to benthic ecosystems; 2) mobilization of sediment contaminants, making them more bio-available; and 3) increasing the amount of suspended sediment in the water column (Montagna et al., 1998). Organisms that are buried must vertically migrate or die (Maurer et al., 1986). Maurer et al.

(1986) demonstrated that many benthic organisms were able to migrate vertically through 35 inches of dredged material under certain conditions; however, the species present in early successional stages of recovery are not the same as those buried by the dredged material. Although vertical migration is possible, most organisms at the center of the disturbance do not survive, and survivability was shown to increase as distance from the disturbance increased (Maurer et al., 1986). EH&A (1998b) found few differences in species assemblages in placement areas and nearby SAV beds in the ULM and LLM. Of the placement areas examined, six had been used within 5 years and six had not been used for 7 to 13 years at the time of the sampling. The general conclusion was composition of benthic assemblages reflected a geographic rather than placement-related trend, and that disposal practices had little influence on the composition of the benthic communities in the Laguna Madre. In a study of six placement areas from the ULM and LLM, Sheridan (1999) found that the chronic effects of dredged material placement on benthic communities were limited to the immediate vicinity of the deposit area and that after 3 years a major recovery was in progress. However he found that it may take the benthic community as long as 5 to 10 years to recover fully from burial by dredged material placement. It is expected that detrimental impacts to the benthic community would result from the No-Action alternative and the DMMP alternative; however, the degree of impact would depend on the frequency of maintenance dredging. At placement areas where levees will be built out into the open water, a portion of bay bottom will be lost during construction.

Repeated dredging in one place may prevent benthic communities from full development (Dankers and Zuidema, 1995). Excavation destroys the community that previously existed but creates new habitat for colonization (Montagna et al., 1998). Because of this, excavation can actually maintain high rates of benthic productivity (Rhoads et al., 1978). By repeatedly creating new habitat via disturbance, new recruits continually settle and grow. However, these new recruits are always opportunistic, small, surface-dwelling organisms with high growth rates and densities. Large, deep-dwelling organisms that grow slower and live longer are lost to the area of repeated excavation. In this way, excavation may not cause a decrease in production, but rather a large shift in community structure (Montagna et al., 1998). Depending on the dredging cycle frequency, the benthic community structure and abundance may never return to pre-placement levels, as Sheridan (1999) indicates.

Potential beneficial effects of the suspended material associated with dredging operations include a resuspension of nutrients, absorption of contaminants from the water column, and addition of a protective cover allowing certain nekton to avoid predation (Stern and Stickle, 1978). As with the various potential detrimental effects, the importance of each of these latter effects would vary among groups and with the physiochemical parameters existing at the time and location of dredging and placement operations. Material to be dredged is not contaminated and should not pose contamination issues with respect to aquatic communities.

In the unlikely event of a petroleum product spill, benthic fauna may be killed, but phytoplankton may be adversely or favorably affected by oil spills. It is unlikely that an oil spill in the Laguna Madre would result in significant, long-term impacts to either phytoplankton or benthic communities, since these organisms have the ability to recover rapidly from a spill due primarily to their rapid rate of reproduction and to the widespread distribution of dominant species.

Table 4-2 shows the differences between the area of open-bay bottom and seagrasses, where the benthos live. Inside the PAs, as with seagrasses previously noted, there will be more impacts to open-bay bottom with the DMMP alternative (2,886 acres) (Table 4-1), relative to the No-Action alternative (2,490 acres) as some PAs are expanded and enclosed in levees. However, in the case of seagrass, but not open-bay bottom areas, the loss inside the PAs will be more than compensated for outside the PAs for a net gain of seagrass and the much smaller loss of open-bay bottom with the DMMP alternative (see Table 4.2). Therefore, the DMMP alternative should provide an overall benefit for the benthic communities in the Laguna Madre.

An examination of Table 4-3 for impacts from expanded and new PAs shows that approximately 289 more acres of open-bay bottom, including side channels, will be impacted by the DMMP alternative than by the No-Action alternative. This includes three PAs (197, 202, and 222) where fewer acres are impacted and seven PAs (186, 195, 199, 220, 221, 233, and 234) where more impacts will occur. The greatest single impact is, of course, at PAs 233 and 234, which are being moved into deep water to decrease resuspension in this high-current area and reduce impacts to seagrass. Given the large amount of open-water habitat in the Laguna Madre (69,800 acres, calculated from information provided in Onuf 1996b), this is not considered a significant impact, especially considering the benefits of a reduction in turbidity and impacts on seagrass that will accrue to seagrasses and algal/sand flats as an overall result of implementation of the DMMP alternative.

4.5.3 Essential Fish Habitat

Current practice for Reaches 1, 2, 4, 5, and 6 is open-bay disposal and upland confined placement for Reach 3. With the No-Action alternative, dredging required for regular maintenance of the GIWW and associated open-bay placement of the dredged maintenance material would continue as usual.

EFH for adult and juvenile brown, white, and pink shrimp; red drum; as well as adult gray snapper and Spanish mackerel occurs in the Laguna Madre ecosystem and may include estuarine emergent wetlands, estuarine mud, sand, sand and shell substrates, SAV, and estuarine water column. However, there is no shell substrate in the areas to be dredged for the DMMP alternative. The closest oyster reef in South Bay is roughly 2.5 miles away from PA 240 and separated by the Brownsville Ship Channel. The serpulid reefs and coquina rock outcrops are located a good distance away from the nearest placement areas. Approximately 4,887 acres of open water, based on open-bay bottom impacts (Table 4-1), would be affected by the DMMP alternative relative to the 4,772 acres for the No-Action alternative, an increase of 115 acres (2.4%) (Table 4-2).

Initial placement operations would cover benthic organisms with dredged material. Recovery of some benthic organisms would likely occur relatively quickly, although the assemblage in the dredged material might differ from the assemblage that existed at the placement area prior to construction. Sheridan (1999) found that recovery of the benthic community would continue for at least 18 months for some parameters and beyond 3 years for others.

With either alternative, increased water column turbidity during dredging would be localized and temporary and reduced with the DMMP alternative. Teeter (2003) found that the area of high turbidity extended roughly to the edge of the fluid mud flow, or about 1,300 to 1,650 feet from the discharge pipe. Modeling of dredged material discharge in the Laguna Madre determined that turbidity caused by dredging only lasts on the order of weeks to a few months, and therefore impacts to the estuarine water column would be minimal (Teeter, 2003). Material to be dredged is not contaminated and should not pose contamination issues with respect to EFH. Accidental spills have the potential to impact EFH, and larval and juvenile finfish could be affected significantly should a spill occur. Larval and juvenile finfish tend to be more susceptible to spills than adults and could be affected extensively by a spill during their active immigration periods. Due to their lack of mobility, they are less likely to be able to avoid these areas and could be negatively impacted if a spill were to occur; however, there would be no increase in spill chances with the DMMP alternative and spills of a toxic substance, such as diesel, have not occurred in the past in Laguna Madre.

The DMMP alternative would impact adult and juvenile brown, white, and pink shrimp; red drum; as well as adult gray snapper; however, these impacts would be minimized by reducing impacts to SAV beds. Harmful effects would occur if sediment covers fish spawning grounds and bottom areas critical to juveniles. However, with the DMMP alternative, runoff of dredged material onto SAV would be reduced through the use of training levees and total confinement of some PAs. If disposal operations are completed before the seasonal peak in spawning or larval abundance, recovery would be more rapid (Hirsch et al., 1978). Proposed mitigation, beneficial use, and reduction in impact areas amount to 1,801 acres of EFH creation, with the majority of this acreage proposed as shallow-water habitat. The DMMP alternative proposes to reduce impacts to SAV by 1,307 acres (Table 4-2), relative to the No-Action alternative, using dredged material in a manner recommended by the ICT.

The FEIS will serve to initiate EFH consultation under the Magnuson-Stevens Fishery Conservation and Management Act. The NMFS will review the FEIS and provide comments to EFH impacts.

4.6 WILDLIFE RESOURCES

4.6.1 No-Action Alternative

There would be no net increase in impacts to terrestrial wildlife species or habitats within or near the project area as a result of the No-Action alternative. Dredging, conveyance, and placement activities would continue under the existing plan. Impacts to terrestrial wildlife and habitats may include short-term effects resulting from the noise and physical disturbance of dredging activities, as well as long-term effects resulting from habitat modification. Some dredged material would be placed in deep-water areas and would not impact terrestrial wildlife species or habitat. The net effect of these impact types on local wildlife would most likely be minor.

Dredging and placement activities may result in increased turbidity, causing temporary local impacts to aquatic communities and habitats. This, in turn, may impact local birds by temporarily reducing the available food supply. This impact may be more noticeable at sites located near rookeries. Several studies (Hartley and Fisher, 1936; Stott, 1936; Doan, 1942; and Jermolajev, 1958) mention the tendency of turbidity to concentrate food species such as small fish associated with plankton near the surface where birds may prey upon them. However, the feeding efficiency of marine birds does not appear to be significantly affected by water opacity. Sessile, ground-dwelling animals, such as reptiles, amphibians, and small mammals, may suffer loss of habitat or life during the placement of dredged material.

The noise of equipment and increased human activity during dredging, conveyance, and placement activities may disturb some local wildlife, particularly breeding birds. These impacts are local and temporary and are not expected to be significant considering the availability of nearby suitable habitat and the mobility of the birds, especially considering the limitation on placement on rookeries during the nesting season.

The slightly increased possibility of accidental spills of oil, chemicals, or other hazardous materials during dredging activities also poses a threat to the aquatic community and, thus, the food source of many coastal birds in the area. These effects are expected to be temporary and without significant long-term implications.

Long-term effects to terrestrial wildlife species and habitats would occur primarily as a result of habitat modification. Placement of dredged material on tidal flats and emergent dredged material placement areas could result in the permanent loss of nesting, foraging, loafing, and roosting habitat for birds. These impacts would be localized and are not expected to be significant considering the availability of nearby suitable habitat and the mobility of the birds. According to the Texas Colonial Waterbird Database (FWS, 2002c), a total of 35 bird rookeries occur on tidal flats and emergent dredged material placement areas adjacent to the GIWW, 23 of which are located in existing or proposed placement areas (Appendix B). Seven of the 23 rookeries encompass multiple placement areas. The majority of placement areas currently have bird management plans for dredging, conveyance, and placement operations, which generally allow for the avoidance of placement in major rookeries (e.g., North and South Bird Islands) and include restrictions on placement of material during the breeding season in those areas periodically used. There would be a continued potential for predation of colonial waterbird rookeries on existing placement areas that are in close proximity to the mainland, barrier islands, or other islands.

Impacts to waterfowl species and habitats would occur primarily as a result of habitat modification. Dredging and placement activities, particularly open-bay placement of dredged material, could have an adverse effect on seagrass beds, which provide the primary food source for many species of wintering waterfowl including redheads and northern pintails. A maximum of 4,784 acres of SAV would be negatively impacted by the No-Action alternative, which is 1,307 greater than the 3,477 acres of SAV negatively impacted by the DMMP alternative. Thus, the No-Action alternative would result in greater impacts to SAV, and thus waterfowl foraging habitat, than the DMMP alternative.

A majority of maintenance material from reaches 1, 2, 4, 5, and 6 would be placed in unconfined open-bay placement areas, although several confined and semiconfined placement areas are also used. Maintenance material from Reach 3 would be currently placed in confined and semiconfined upland placement areas in the Land Cut. In general, placement of dredged material in open-bay placement areas would result in fewer impacts to terrestrial wildlife species and habitat than placement in upland placement areas. Impacts to terrestrial wildlife from open-bay placement would be limited to areas where material would be placed above the mean high tide mark or in tidally influenced areas which provide nesting, foraging, loafing, and roosting habitat for birds. Impacts to waterfowl species from open-bay placement would primarily be limited to areas where material would be placed directly in SAV, which provide foraging habitat for many waterfowl species. Increased turbidity, as result of material placement could also have a negative indirect effect on SAV and thus waterfowl foraging habitat. These impacts would be localized and are not expected to be significant considering the availability of nearby suitable habitat and the mobility of the birds.

4.6.2 Dredged Material Management Plan (DMMP) Alternative

Impacts to terrestrial wildlife species or habitats within or near the project area as a result of the DMMP alternative may include short-term effects resulting from the noise and physical disturbance during dredging activities, as well as long-term effects resulting from habitat modification. Some dredged material would be placed in deep water areas and would, therefore, not impact terrestrial wildlife species or habitat. The net effect of these impact types on local wildlife would most likely be minor.

Dredging and placement activities may result in increased turbidity, causing temporary local impacts to aquatic communities and habitats. This in turn may impact local birds by temporarily reducing the available food supply. This impact may be more noticeable at sites located near rookeries. During the placement of dredged material, sessile, ground-dwelling animals, such as reptiles, amphibians, and small mammals may, suffer loss of habitat or life.

The noise of equipment and increased human activity accompanying dredging, conveyance, and placement activities may disturb some local wildlife, particularly breeding birds. These impacts are local and temporary and are not expected to be significant considering the availability of nearby suitable habitat and the mobility of the birds.

The slightly increased possibility of accidental spills of oil, chemicals, or other hazardous materials during dredging activities compared with non-dredging periods also poses a threat to the aquatic community and, thus, the food source of many coastal birds in the area. These effects are expected to be temporary and without significant long-term implications.

Long-term effects to terrestrial wildlife species and habitats would occur primarily as a result of habitat modification. Placement of dredged material could result in the permanent loss of nesting, foraging, loafing, and roosting habitat for birds; however, these impacts are expected to be temporary and local, and dredging activities would be restricted to winter months to reduce impacts to local populations of nesting birds. Numbers of nesting birds appear to be declining for some species, which could be accelerated or diminished by the effects of dredging. According to the Texas Colonial Waterbird Database (FWS, 2002c), a total of 35 bird rookeries occur on emergent dredged material placement areas adjacent to the GIWW, 23 of which are located on existing or proposed placement areas (Appendix B). Seven of the 23 rookeries encompass multiple placement areas. The majority of placement areas currently have bird management plans for dredging, conveyance, and placement operations, which generally avoid known major rookeries (e.g., North and South Bird Islands) and include restrictions on placement of material during the breeding season. Current bird management plans would be continued on applicable sites.

Impacts to waterfowl species and habitats would occur primarily as a result of habitat modification. Dredging and placement activities, particularly open-bay placement of dredged material, could have an adverse effect on seagrasses as a result of increased turbidity and modification of the habitat. Seagrasses provide the primary food source for many species of wintering waterfowl including redheads and northern pintails. However, based on document reviews, SAV would experience an area-wide increase under the DMMP alternative and would therefore result in an increase in waterfowl foraging habitat. A maximum of 3,477 acres of SAV would be negatively impacted by the DMMP alternative, which is 1,307 fewer than the 4,784 acres of SAV negatively impacted by the No-Action alternative.

According to the DMMP, it appears that material placement activities would have a positive effect on colonial waterbirds by enhancing or expanding many of the existing bird rookeries, as well as creating new habitat. Maintenance material from reaches 1, 2, 4, 5, and 6 would be placed in confined, semiconfined, and unconfined open-bay placement areas. Although PA 176 would be described as an upland confined placement area, it would be located on an existing emergent dredged material placement area. Maintenance material from Reach 3 would continue to be placed in existing confined and semiconfined upland placement areas in the Land Cut. In general, placement of materials in open-bay placement areas would result in fewer impacts to terrestrial wildlife species and their habitat than placement in upland placement areas. Impacts to terrestrial wildlife from open-bay placement would be limited to areas where material would be placed above mean high tide or in tidally influenced areas which provide nesting, foraging, loafing, and roosting habitat for birds. Impacts to waterfowl species from open-bay placement would primarily be limited to areas where material would be placed directly in SAV, which provide foraging habitat for many waterfowl species. Increased turbidity, as result of material placement could also have a negative indirect effect on SAV and thus waterfowl foraging habitat. However, as discussed previously, the DMMP alternative would result in an area-wide increase in SAV, thus potentially enhancing waterfowl foraging habitat. These impacts would be localized and are not expected to be significant considering the availability of nearby suitable habitat and the mobility of the birds.

Large emergent areas, created as a result of placement activities, provide for excellent colonial waterbird rookery sites, but only where the emergent areas are adequately isolated by open water habitat. Emergent areas that are in close proximity to the mainland, barrier islands, or other islands, or are separated only by shallow water habitat, allow access and/or provide habitat for terrestrial predators such as coyotes and raccoons, potentially resulting in increased predation of waterbirds and their nests. The DMMP alternative would minimize the placement of materials in close proximity to the mainland, barrier islands, and other islands, thus minimizing the potential for increased predation by terrestrial wildlife. Also, channels between some PAs will be deepened and widened to help reduce predation access (see DMMP for specific actions). Conversely, it would result in the creation of several PAs large enough to sustain a population of predators and could, in those instances, result in increased predation of waterbirds and their nests. There is no way to quantify these impacts, but the DMMP decision-making process should continue to assess the impacts of creating large emergent areas where the potential for establishment of predator populations would be aided by such creation.

Both the No-Action and the DMMP alternatives should not result in substantial (if any) losses to migratory birds (particularly those considered of special concern and measures will be taken to enhance migratory bird habitats). Also, the DMMP alternative would establish management plans on some emergent dredged material placement areas and would restrict placement activities from occurring during the primary bird nesting season (summer). Therefore, take under the Migratory Bird Treaty Act is not expected to occur.

4.7 THREATENED AND ENDANGERED SPECIES

4.7.1 Plants

Records indicate that no Federally or State-listed plant species are known to occur within 2 miles of the proposed project activities. No suitable habitat for the species discussed in Section 3.7-1 exists in any of the existing or proposed placement areas. No dredged material placement is planned, as part of the No-Action or DMMP alternatives, on upland or terrestrial habitats except for the area of the Land Cut. Therefore, no impacts to protected plant species are anticipated from either the No-Action or DMMP alternatives.

4.7.2 Wildlife

The No-Action and DMMP alternatives would result in little or no immediate direct impacts to any protected species or designated critical habitat within the project area. Changes to habitats, over time, would be expected as a result of various natural influences (e.g., floral succession and subsequent use/abandonment by various faunal species, storm events of inland or coastal origin, natural continual wave action, etc.). In general, dredged material placement activities associated with the No-Action and DMMP alternatives may affect habitats used by the piping plover and state-threatened colonial waterbirds.

Both the No-Action and DMMP alternatives may have immediate short-term impacts on selected protected species and/or protected species' habitats within the vicinity of the project. Some individuals may be temporarily displaced due to project disturbances. Abundant suitable habitats occur within the vicinity of the preferred alternative to allow for such temporary displacement, and most disturbances would be of a duration short enough to allow for a prompt return to pre-project patterns. Those species with the ability to relocate in response to project activities would only be subject to minimal short-term impacts. Increased boat traffic within the project area during maintenance dredging and placement may also temporarily disturb various aquatic species and may increase erosion/sedimentation in some areas. However, these impacts would be considered short-term and generally insignificant.

Specific impacts from the project alternatives for the protected species identified as potentially occurring in the project area counties are further detailed in the following sections.

4.7.2.1 Amphibians

Two State-listed amphibian species, the south Texas siren and the black-spotted newt, are known to occur within the project area. In addition, the Rio Grande lesser siren (SOC) is also known from the project area. Because no freshwater bodies would be affected by the project, effects on this species should be minimized. Although both are known to occur on tidal flats of LANWR immediately west of PAs 224 and 225, under the DMMP the ICT proposes to fully confine these placement areas. This should reduce the likelihood that dredged material would be deposited on individuals of either species, since they would not be able to cross the levee.

4.7.2.2 Birds

Several species of birds that receive protection at the Federal or State level are listed as potentially occurring within the project area counties. Many of these species, such as the northern Aplomado falcon, mountain plover, American peregrine falcon, zone-tailed hawk, cactus ferruginous pygmy-owl, northern beardless tyrannulet, rose-throated becard, tropical parula, or Texas Botteri's sparrow, are not likely to occur near project activities associated with either the No-Action or DMMP alternatives because they are more land-based species that rarely venture into the open-bay environs. The Eskimo curlew is likely extinct; thus, it would be unlikely to occur in the project area. While least terns have been documented in rookeries on numerous placement areas within the project area, it is likely that these occurrences are of the non-listed coastal subspecies as opposed to the interior subspecies.

Avian SOC, including the northern gray hawk, ferruginous hawk, loggerhead shrike, cerulean warbler, Texas olive sparrow, Sennett's hooded oriole, Audubon's oriole, and Brownsville common yellowthroat, are not likely to occur near project activities associated with either the No-Action or DMMP alternatives because they are more land-based species that rarely venture into the open-bay environs. The black rail and black tern, both SOC, may occur within the project area; however, impacts to these species are not anticipated.

Other species, such as the brown pelican, bald eagle, whooping crane, wood stork, Arctic peregrine falcon, white-tailed hawk, and common black-hawk are species that typically nest further northeast along the coast and/or inland, but which may appear in the project area for feeding or roosting or during migration. These species should not be impacted by either alternative due to their ability to flee the area during periodic disturbances.

In general, potential impacts to protected birds from either the No-Action or DMMP alternative could likely result from a variety of factors. The primary direct impact would be from disturbance during dredging and placement activities which may cause roosting birds to be temporarily displaced. Since such activities are short-term and periodic, abundant suitable habitats occur within the Laguna Madre system and would allow for short-term displacement. It is anticipated that use of these areas would resume following cessation of dredging and placement activities. Similarly, it is likely that the expansion or addition of placement areas as well as proposed measures to increase the surface area of bird islands associated with the DMMP alternative would ultimately result in new habitat creation for wading and shorebirds.

Dredging activities for both alternatives could also cause temporary, short-term impacts to aquatic communities including increased sedimentation and turbidity which may lead to a reduction in food supplies or loss of visibility, thus altering waterfowl feeding strategies on a short-term basis. Conversely, the same dredging activities could increase feeding opportunities for some birds by disturbing various aquatic organisms making them easier prey. Also, the possibility for small accidental spills of petroleum products associated with dredging activities could also present a potential, albeit small, threat to aquatic communities and, subsequently their food supply.

Specific potential impacts to those protected avian species most likely to be impacted by the project are described below.

Piping Plover

Although approximately 6,588 acres under the No-Action alternative and 6,210 acres under the DMMP alternative of piping plover critical habitat would be affected by project activities (primarily placement of dredged material), the No-Action and DMMP alternatives should not directly affect the piping plover since these areas do not contain the primary constituent elements needed by piping plovers. While the piping plover may occur throughout the project area, known use of existing placement areas are concentrated in the ULM (EH&A, 1993; TXBCD, 2002; PBS&J, 2001). In surveys of piping plover use of dredged material placement areas conducted in relation with this EIS, EH&A (1993, 1997b) recorded piping plover use of placement areas in reaches 1 and 2 only. Studies performed by Zonick et al. (1998) and Drake et al. (1999) found no piping plovers on dredged material placement areas in the LLM. Because of the limited amount of suitable habitat (habitat with the primary constituent elements needed by the birds) on active placement areas and the great amount of suitable habitat adjacent to these placement areas, impacts would be minimal. In addition to the potential effects described below, there is also the possibility that some suitable habitat would be created by either alternative as currently submerged portions of placement areas become emergent, especially if sufficient time elapses between placement activities allowing algal mats to develop.

All critical habitat in Reach 1 is delineated along Padre Island and will not be impacted by placement of dredged material at PAs 175 through 191 (Figure 3-3). However, of all the project area reaches, Reach 1 has had the most piping plover observations on placement areas (EH&A, 1993, 1997b; Zonick et al., 1998; Drake et al., 1999; TXBCD, 2002). This is likely due to the limited frequency of use (more than or equal to 7.7 years) that PAs 175 to 185 have undergone, allowing sufficient time for algal mats to develop on the sand flats. PAs 175 through 181 were the only placement areas in this reach where piping plovers have been recently observed (EH&A, 1993; TXBCD, 2002). Because these placement areas are used so infrequently and dredging is expected to continue as currently practiced, impacts to the piping plover from either alternative should be minimized. However, when placement does occur on these sites, suitable habitat (outside designated critical habitat) will be degraded. If enough time passes between placement activities, it is possible that suitable habitat would return. If placement occurs before settling and algal mats are formed, then degradation could become permanent and the site would no longer be attractive to wintering piping plovers. Under the DMMP, levees would be built on some placement areas, such as PA 176, which may train the material away from suitable habitat areas. FWS will be contacted prior to levee construction at PA 176 to ensure no impacts to the piping plover would occur.

Within Reach 2, six placement areas fall within critical habitat unit TX-3 (subunit 3). Four were considered to contain suitable habitat for the piping plover; two of which have documented use by piping plovers (EH&A, 1993). EH&A (1993) found two additional placement areas to contain suitable habitat. Under the DMMP, PA 195 would be expanded to include additional emergent sand flats with a small portion of algal mat, as well as some upland habitat. Additionally, flows out onto tidal flats could raise the elevation, changing tidal flats into more upland habitat, which would not be used by piping plovers. This PA will be examined more closely before placement occurs. The FWS visited the PA and noted that primary constituent elements for the piping plover existed there and some plovers were seen, but a resolution of this concern was not made. However, since the flow will be directed to the south, under the DMMP, the DMMP dredged material placement should not impact the algal flats to the east of the existing or proposed PA 195, as would the No-Action alternative. Therefore, Table 4-2 shows a decrease in impacts to flats. The construction of levees is proposed for some placement areas in this reach under the DMMP, which may train the material away from areas of suitable habitat.

All placement areas within Reach 3 coincide with critical habitat unit TX-3 (subunit 3). Of the seven placement areas within this reach only one, PA 204, was not considered to include suitable habitat due to the existence of levees around its perimeter. Several other placement areas within Reach 3 are also partially confined within levees. During surveys of this reach, EH&A (1993) recorded no piping plovers using these placement areas, although use of the adjacent tidal flats has been documented (TXBCD, 2002). No changes are proposed for placement areas within this reach under the DMMP. No impacts are anticipated from either alternative in Reach 3.

Within reaches 4, 5, and 6, of the thirty existing placement areas and two new placement areas proposed under the DMMP, only three placement areas in the southwestern portion of TX-3 (subunit 3), and the eastern extent of TX-4 encompass even marginally suitable habitat for the piping plover. Piping plovers were rarely, if ever, observed to use these placement areas (EH&A, 1997b; Zonick et al., 1998; Drake et al., 1999); therefore impacts to the piping plover from direct project activities within this reach are expected to be negligible.

State-threatened Colonial Waterbirds

Three state-threatened colonial waterbirds, the white-faced ibis, reddish egret, and sooty tern, are known to nest on dredged material placement areas within the project area. A total of 32 placement areas within the project area have been recorded as sites of rookeries used by one or all of these birds since FWS (2002c) began the Texas Colonial Waterbird Census in 1973. Within the past 5 years, however, only five placement areas in Reach 1, seven placement areas in Reach 2, no placement areas in Reach 3, six placement areas in Reach 4, two placement areas in Reach 5, and five placement areas in Reach 6 have been used by these birds. The most common of these species in the project area is the reddish egret, whereas the white-faced ibis and sooty tern have recently only nested on placement areas in the project area once and twice, respectively.

Neither the No-Action nor the DMMP alternative should directly impact these State-listed waterbirds because they are mobile enough to avoid direct impacts from dredged material placement. Furthermore, numerous other rookeries exist in the vicinity of the placement areas that would allow for temporary displacement. Nesting efforts by these birds could be disrupted by noise associated with project activities, although such affects would be temporary. Under the DMMP alternative, impacts to these species would be lessened by various aspects of the plan, including avoiding islands or portions of islands on some placement areas where birds are nesting; building up or reinforcing emergent habitats on several placement areas for bird use; or avoiding placement activities during the primary nesting season (summer). Thus, potential impacts to the sooty tern, reddish egret, and white-faced ibis would generally be considered short-term and insignificant.

4.7.2.3 Fish

No Federally listed and only three State-listed species of fish are known to occur within the project area counties. These fish are found mostly in freshwater coastal streams, and occurrences of these species in Texas is uncommon. In addition, the high salinity of the Laguna Madre would most likely preclude their occurrence within the project area. Therefore neither the No-Action nor DMMP alternative should have any immediate impacts on listed fish species. Any individuals that may occur within the project area are mobile enough to avoid dredging activities. A temporary increase in turbidity would be expected as the result of dredging activities; however, these conditions would be temporary. Abundant suitable habitats exist nearby that would allow for species dispersal from the area of impact.

Most of the NMFS candidate species occupy offshore waters in the Gulf of Mexico and are not common to the project area. The saltmarsh topminnow is the only species which inhabits estuaries, however it is not found in the Laguna Madre. Therefore, no significant detrimental effects on the listed and candidate species are expected with the No-Action or DMMP alternative.

4.7.2.4 Mammals

West Indian Manatee

The No-Action and DMMP alternatives should have no immediate impacts on the West Indian manatee. Occurrences of this species within the project area are extremely rare; thus it is not likely that manatees would be impacted by dredging or placement activities. In the event a manatee entered the project area, its primary threats would be from boat traffic associated with dredging. However, manatees are mobile enough to avoid most potential impacts from slow-moving boats and machinery, but many can still be injured, often fatally, each year as the result of impacts with high-speed boats.

Other Mammals

The No-Action and DMMP alternatives should have no impacts on the State and Federally listed or SOC terrestrial mammals potentially occurring in the project area counties. Neither alternative should have any impacts on terrestrial habitats other than existing placement areas that may be used on a limited and/or accidental basis by terrestrial mammals. The Federally listed species (the jaguar (considered extirpated), jaguarundi, ocelot, and black bear) are considered extremely rare or absent from the project area and require dense vegetative cover not present near project activities; thus any occurrence would likely be considered accidental. Therefore, it is not likely that proposed activities would have any effect on these species.

4.7.2.5 Reptiles

Sea Turtles

The loggerhead, Kemp's ridley, and green sea turtles are the most likely of the five Federally and State-listed sea turtles to occur within the project area. Although highly unlikely, if sea turtles occur in the project area, they may be negatively impacted by dredging activities. Dredged material placement would increase turbidity in the project area, but sea turtles are mobile enough to avoid disturbed sites. Project impacts would be temporary and local in nature. Cutterhead suction dredges would be used which move very slowly and can be avoided by all species of sea turtles. Studies have indicated that cutterhead dredges, since they act on only small areas at a time, do not impact sea turtles (NMFS, 1998). Since all dredging of the project area would be performed by cutterhead dredges rather than hopper dredges, no impacts to sea turtles from maintenance dredging operations are anticipated.

American Alligator

The No-Action and DMMP alternatives should not affect the American alligator. Although alligators are known to occur within virtually every bay system along the Texas coast, including the ULM and LLM, they would likely avoid locations where dredging and placement activities were actively occurring.

Other Reptiles

Several other species of reptiles are protected by the State as described in Section 3.7.2.5. In addition, there are two Federal reptile SOC in the project area, the Gulf salt marsh snake and the Texas diamondback terrapin. Neither the No-Action nor DMMP alternatives should have any immediate impacts on any of the reptiles that are State-listed or considered SOC.

4.7.2.6 Mollusks

Texas Hornshell

The No-Action and DMMP alternatives should have no impacts on the Texas hornshell. This extremely rare candidate species is only known from the Rio Grande system. This species is highly unlikely to occur in the project area.

4.7.2.7 Insects

Two insects identified by FWS as SOC are potential in the project area. Neither the No-Action nor DMMP alternatives should have any immediate impacts on either of these insects.

4.8 HAZARDOUS, TOXIC AND RADIOACTIVE WASTES

Impacts from the DMMP alternative on hazardous material sites would be similar to those from the No-Action alternative.

A regulatory agency database search and a site reconnaissance were performed in conjunction with a previous HTRW study (EH&A, 1995). This study was performed to determine the location and status of sites regulated by the State of Texas and the EPA. The study revealed several regulated facilities and reported spills within the project area. However, none of these regulated facilities or spill incidents appear to pose an environmental concern for the project.

According to the 1995 HTRW study, the Railroad Commission of Texas reports a total of 18 active oil/gas wells in the immediate vicinity of the GIWW, none of which are on PAs, and eleven petroleum pipelines that cross the GIWW.

4.8.1 <u>Hazardous Material Impacts to the Existing Environment from Project Activities</u>

The impacts from material use and handling during dredging activities associated with the project pose a minimal risk of impacts to the environment. Typical impacts may include leaks or small spills associated with heavy equipment and floating facilities. However, these impacts would be minimal and typically do not pose a significant risk to the environment. The owners and/or operators of the pipelines are typically notified prior to maintenance dredging activities so that pipelines can be marked and avoided.

4.8.2 <u>Hazardous Material Impacts to the Project from Operation Activities</u>

There are no reported impacts to the environment from historical operation of the existing channel.

4.9 AIR QUALITY

4.9.1 No-Action Alternative

For the No-Action alternative, the maintenance dredging activities in the GIWW will continue, resulting in minor short-term impacts on air quality in the immediate vicinity. Impacts to air quality would result from the combustion of diesel fuel during dredging and placement operations resulting in air emissions of nitrogen oxides (NO_x), CO, volatile organic compounds (VOC), PM, and SO_2. The amount of fuel combustion emissions would be directly related to the type and size of equipment and the amount of dredging required. Maintenance is performed by contracted cutterhead suction dredges, and materials dredged are pumped into both land and open-bay placement areas using hydraulic pipeline attachments. Historically, for each placement area, dredging has occurred on a frequency ranging from about 2 years to 49 years. The duration of dredge application at the placement areas ranges from about 1 day to 20 days. As previously noted, the main channel of the GIWW requires maintenance dredging every 23 to 60 months in selected reaches to remove approximately 200,000 cy to 3 MCY of sediment (USACE, 1994). Based on a historical average of about 1.97 MCY, the estimated air emissions for the No-Action alternative are summarized in Table 4-4.

4.9.2 Preferred Alternative (DMMP)

Because the amount of dredging expected for the preferred alternative is expected to be the same as for current activities, or a little less if dredging is reduced by the DMMP, it is expected that air emissions from the preferred alternative would result in approximately the same or slightly less annual average emission rates and in minor short-term impacts on air quality in the immediate vicinity of the dredged site. Although each dredging episode may be relatively independent of one another, separated by frequency, duration and spatial distance, there may be some overlap.

TABLE 4-4

MAINTENANCE DREDGING
ESTIMATED AVERAGE ANNUAL EMISSIONS BY REACH *
(tons per year)

Reach	County	PM_{10}	SO_2	NO_x	VOC	CO
1	Nueces/Kleberg	0.23	2.67	7.97	0.23	1.83
2	Kleberg/Kenedy	0.37	4.30	12.76	0.37	2.92
3	Kenedy	0.23	2.61	7.76	0.23	1.78
4	Kenedy/Willacy	0.38	4.41	13.1	0.38	3.0
5	Willacy/Cameron	0.05	0.59	1.74	0.05	0.40
6	Cameron	0.29	3.39	10.1	0.30	2.30
TOTAL		1.56	17.99	53.56	1.57	12.23

* Based on a dredge pump capacity of 1,800 cy per hour and a 20-hour dredging day.

4.9.3 Air Quality Impacts

Although there are dispersion modeling tools available to estimate local air quality impacts, these models are most accurate at estimating impacts from those facilities from which emissions occur at well-defined, stationary emission points. In the case of this project, local dispersion of emissions cannot be characterized with accuracy because they would be emitted from mobile dredging equipment sources that would operate intermittently and at varying locations. Additionally, the level of activity would be variable.

As previously noted, VOCs and nitrogen oxides can combine under the right conditions to form ozone, possibly increasing the concentration of ozone in the region. However these reactions take place over a period of several hours with maximum concentrations of ozone often far downwind of the precursor sources. Regional dispersion models available to characterize VOC and NO_x and their contribution to O_3 production are not intended to estimate a specific project's contribution to regional O_3 concentrations. Therefore, regional dispersion models would not be useful in estimating the project's construction and operational impact on regional O_3 concentrations.

Airshed pollutant loading determined by the magnitude of emissions expected to result from the dredging activities compared with area emissions can be used to estimate air quality impacts of the criteria pollutants. Based on available air emissions provided on the EPA's AIRData website (EPA, 2002), Table 4-5 shows the air emissions inventory for the counties within the project area and compares it to the emissions from either the DMMP or No-Action alternatives. The county emissions data are the most recently available and include emissions from area, mobile, and point sources based on emissions inventory information for 1999. The emissions for either alternative are separated according to the geographical location of the placement areas within each county.

As shown on Table 4-5, estimated emissions of each air contaminant from maintenance dredging for the preferred alternative would make up less than one percent of the existing emissions inventory for Nueces, Willacy and Cameron Counties. In Kleberg County, emissions of PM_{10}, NO_x, VOC and CO would also make up less than one percent of the existing emissions inventory for 1999. Emissions of SO_2 would make up about 2 percent of the existing inventory. Emissions of SO_2 and NO_x would make up about 8 percent and 3 percent, respectively, of the existing emissions inventory for Kenedy County with the other air contaminants each making up less than 1 percent. Total emissions would make up less than 1 percent of the total emissions for each county.

TABLE 4-5

SUMMARY OF AIR EMISSIONS BY PLACEMENT AREA COMPARED WITH NUECES, KLEBERG, KENEDY, WILLACY, AND CAMERON COUNTY EMISSIONS FOR 1999
(tons per year)

County/ Placement Area	PM_{10}	SO_2	NO_x	VOC	CO	Emissions Total
Nueces	26,368	13,172	51,475	30,304	108,444	229,763
PA 175–179	0.0079	0.092	0.27	0.008	0.06	0.44
% of County Emissions	0.00003	0.0007	0.00052	0.00003	0.00006	0.0002

TABLE 4-5 (Cont'd)

County/ Placement Area	PM_{10}	SO_2	NO_x	VOC	CO	Emissions Total
Kleberg	6,058	230	4,834	4,556	9,494	25,172
PA 180–197	0.38	4.42	13.1	0.38	3.0	21.3
% of County Emissions	0.006	1.92	0.27	0.008	0.03	0.08
Kenedy	972	104	968	3,120	4,906	10,070
PA 198–218	0.69	8.02	23.8	0.70	5.46	38.7
% of County Emissions	0.07	7.71	2.46	0.02	0.11	0.38
Willacy	9,166	187	2,158	2,489	6,893	20,893
PA 219–223	0.14	1.59	4.71	0.14	1.08	7.7
% of County Emissions	0.002	0.85	0.22	0.006	0.02	0.04
Cameron	38,564	2154	17,049	16,415	75,300	149,482
PA 224–240	0.33	3.87	11.5	0.34	2.62	18.7
% of County Emissions	0.0009	0.18	0.07	0.002	0.003	0.01

Source: EPA, 2002.

The estimated emission rates for the maintenance operations are relatively minor and spatially spread out. In addition, the frequency would be intermittent and of relatively short-term duration for each segment. The climatological conditions will also allow for dispersion of air emissions such that their impact in the project area are reduced. Therefore, emissions from the proposed maintenance dredging are not expected to result in a serious impact to the regional air quality and are not expected to differ significantly from present maintenance dredging operations. As monitoring data for the past several years indicate compliance with the NAAQS for the project area, emissions from the preferred alternative are also expected to comply with the NAAQS.

4.10 NOISE

In general, sensitive receptors include residences, schools, churches, and other facilities that use, and are dependent to some extent, on relatively quiet noise environments. The closest noise-sensitive receptors within the project area are condominium developments located approximately 1,300 feet to the east of PA 176 and PA 177. During current dredging activities, there would be an increase of noise emissions at the dredging and placement areas. The dominant source of noise from most construction equipment and machinery is the engine, usually diesel. Noise emission levels of a diesel-powered cutterhead dredge similar to the type used within the project area have been measured at approximately 79 dBA, at a distance of 160 feet (USACE, 2001). Typical construction noise is decreased approximately 6 dBA per doubling distance from its source. Therefore, it can be assumed that the above mentioned condominium development is exposed to noise levels of approximately 61 dBA during dredging activities. These activities, however, are short term and would not substantially raise noise levels at the noise-sensitive receptors. Furthermore, the condominium developments are not likely to be subjected to these noise levels very often since PAs 176 and 177 have been used only once since 1949.

Noise from dredging activities would be essentially the same under either the No-Action alternative or the DMMP alternative. Because the DMMP alternative would use the existing facilities, a certain amount of noise already occurs at the sites. The DMMP alternative is not expected to increase noise levels above those of the current dredging and placement activities.

4.11 CULTURAL RESOURCES

It is not anticipated that maintenance dredging along the Laguna Madre section of the GIWW under either the No-Action or DMMP alternative will have any adverse impacts on terrestrial cultural resource sites. There is also a low probability that recorded submerged prehistoric sites might be impacted within the dredged channel. The file review did not identify any recorded terrestrial archeological sites near the dredged channel or the placement areas.

There are no recorded shipwrecks in the vicinity of the new placement areas; however, there is a potential for unrecorded wrecks to be present in some of these areas. These shipwrecks would be shallow-draft vessels for which there would be little or no record of their sinking. The areas of concern to the State Marine Archeologist (Hoyt, 2003) are those north of Baffin Bay and those south of the Port Mansfield Channel. The area north of Baffin Bay was not used as a major shipping route due to the shallowness of the water, but local commercial traffic did utilize the ULM to transport goods, including produce, from Kenedy and Kleberg counties to the Corpus Christi area. During the Civil War, this route was used to transport cotton southward toward Mexico by way of Point Penascal at the entrance to Baffin Bay (Tyler, 1996). The area south of the Port Mansfield Channel in the LLM may also harbor unidentified wrecks. This area might have been used to ferry cargo between the harbor at Brazos Santiago and destinations further up the Texas coast, such as the King Ranch, using steamboats or sloops. The earliest dates of the commercial fishing industry in the Laguna Madre, likewise, is not well documented; however, it is suspected that fishing was an important activity prior to the twentieth century. Although vessel losses in this area are not well documented in public historical accounts, the potential exists for sunken watercraft connected to significant persons and events in the history of South Texas.

4.12 SOCIOECONOMIC RESOURCES

4.12.1 Population and Community Cohesion

Under the No-Action alternative, during the 50-year life-of-project (LOP), population growth within the five project area counties would continue as forecasted by the TWDB (see Section 3.12.1, Population). To perform ongoing maintenance dredging within the project area, a relatively small number of dredge operators would continue to be imported annually from outside the project area to work the cutterhead suction dredges. Indirect and induced employment associated with maintenance dredging would be relatively minimal and related mainly to supply companies (e.g., petroleum retailers), hotels, grocery stores, banks, medical services, and restaurants.

In addition, the No-Action alternative would have no effect on community cohesion factors such as educational attainment, household tenure, length of household residency, per capita income, or median household income. Additional housing, schools, and services as well as other growth-related social and economic changes should not be required by continuing maintenance dredging under the No-Action alternative, other than what is currently predicted. No residents would be displaced, and negative effects on community cohesion would not be expected.

Effects on population and community cohesion from the DMMP alternative would be negligible and would not differ from those of the No-Action alternative described above.

4.12.2 Employment and Economics

Under the No-Action alternative, the number of workers employed in dredging and placement operations within the five-county project area during the LOP, would be expected to remain the same as the current practice. Dredge operators would continue to be employed on a contractual basis and would likely come from outside the project area. Indirect and induced employment associated with maintenance dredging and placement would be relatively minimal and related mainly to supply companies (e.g., petroleum retailers), hotels, grocery stores, banks, medical services, and restaurants, as is currently the case. Wages and/or income levels associated with employment (other than inflation) within the project area during the LOP are not anticipated to differ from what could be expected during the same time-period with current maintenance practices.

The effect of the No-Action alternative on the local economies of the project area counties during the LOP would be no different than would be expected due to current maintenance practices. The primary economic effects would be limited to local expenditures by dredging workers (e.g., hotels, restaurants, banking, health care), and purchases of fuel and other supplies used for running the dredges and other equipment. These indirect expenditures would have a relatively minimal effect on total economic output and value-added within the five-county project area. This effect would be no different than can be expected from current maintenance practices. Finally, the effect on indirect business taxes that would be collected within the project area would be negligible, as is currently the case.

Effects on employment and economics from the DMMP alternative would be equivalent to those described for the No-Action alternative above.

4.12.2.1 Commercial and Recreational Fishing

Within the project area, effects on commercial and recreational fishing from the No-Action alternative during the LOP would not differ from current maintenance practices. Management practices used in maintenance dredging and placement of dredged material would result in no new effect on the total weight or commercial value of shellfish and finfish caught within the ULM or LLM. Also, the No-Action alternative would not affect the projected number of recreational fishing user-days within the ULM and LLM, beyond existing practices.

Effects on commercial and recreational fishing under the DMMP alternative during the LOP could be considered beneficial. In general, management practices associated with the DMMP alternative would facilitate an increase in SAV growth. However, the degree to which such growth would affect fish populations, and hence commercial and recreational fishing, is considered negligible and unquantifiable. Under this alternative, there would be a minor positive effect on the total weight and commercial value of shellfish and finfish caught within the ULM or LLM. Also, the DMMP alternative would have a positive but negligible effect on the projected number of recreational fishing user-days within the ULM and LLM when compared with the No-Action alternative.

4.12.2.2 Recreation and Tourism

Dredging and placement activities under the No-Action alternative would have little effect on recreation and tourism within the project area. Current maintenance dredging has a positive effect on recreational boating, fishing, and birdwatching cruises within the ULM and LLM, in that it provides for improved boat navigation. However, if there is a negative effect on seagrasses from the present practice, it could have a negative effect on the fisheries of the area. The No-Action alternative would have no effect on other recreational activities such as waterfowl hunting, windsurfing, camping, jet skiing, swimming, shelling, and beach combing. Shoreline fishing and land-based birding activities would also be unaffected. Overall, under the No-Action alternative, the project area would continue to draw thousands of tourists and recreational visitors annually, due to the draw of outdoor recreation and other area attractions. The No-Action alternative would also have no impact on the Coastal Cabins, presently permitted by the GLO, unless the USACE determined the need to place maintenance material on the islands along the GIWW. This is always a possibility, and, since the cabins are within the USACE right of way, they are subject to removal at any time.

Effects on recreation and tourism from the DMMP alternative would be similar to those described above for the No-Action alternative. However, if there is a negative impact on seagrasses associated with the turbidity that results from unconfined open-bay placement, the DMMP alternative would reduce those impacts. One negative impact that the DMMP will have is that there will be an impact on some of the Coastal Cabins, since the ICT recommends that it is in the best interest of the Laguna Madre ecosystem to use the islands, upon which the cabins are located, for active placement. In some cases, the islands will even be leveed, ultimately leading to the loss of the cabins. A table listing the cabins, by PA, can be found in Table 4-6.

4.12.2.3 Waterborne Transportation

Under the No-Action alternative, the GIWW would continue to play an essential role in waterborne commerce through the ULM and LLM. The demand for such products as refined petroleum products, fertilizer, sand, gravel, iron, steel products, sugar, and other products will increase over time, and the demand for this waterborne transportation route will increase as well. By accommodating future demand for transportation of a wide variety of products, the No-Action alternative would continue to benefit the economies of the project area counties through the LOP. These economic benefits would have a

TABLE 4-6

CABINS LISTED IN DREDGED MATERIAL MANAGEMENT PLAN (DMMP)

PC Number	Permit Status	Pier	Pier Length	Cabin to HWM	Elevation	Stilts	DMMP Impacts
PA 178							
1208	T						Likely to be impacted
1258	T						Likely to be impacted
1599	T						Likely to be impacted
1190	A	Y	120	315	2.5	N	Likely to be impacted
PA 179							Likely to be impacted
1167	A	Y	150	35	3	N	Likely to be impacted
1171	A	Y	215	HWM	0	Y (3)	Likely to be impacted
1068	A	Y	150	45	1	Y (1.5)	Likely to be impacted
1493	A	Y	121	57	1	Y(1)	Likely to be impacted
1454	A	Y	72	152	2	Y(3)	Likely to be impacted
1291	P	N					Likely to be impacted
PA 180							Likely to be impacted
1365	A	N		160			Likely to be impacted
1212	A	Y	234	160	2	Y(2)	Likely to be impacted
1032	A	N		160			Likely to be impacted
1107	A	N		160			Likely to be impacted
1025	A	Y	212	46	2	Y	Likely to be impacted
1271	A	Y	150	71	1	Y (2)	Likely to be impacted
1076	T						Likely to be impacted
1297	A	Y	130	80	1	Y (2)	Likely to be impacted
1130	A	Y	118	HWM	0	Y (10)	Likely to be impacted
1389	A	Y	183	70	1.6	N	Likely to be impacted
1303	A	Y	200	100	2	Y (7)	Likely to be impacted
PA 181							Likely to be impacted
1036	A	Y	231	70	1	Y (1)	Likely to be impacted
1067 *	A	Y	173	100	1	Y (6)	Likely to be impacted
1354 *	A	Y	20	80	1	Y (5)	Likely to be impacted
1061	A	Y	40	200	2	N	Likely to be impacted
CL860009	A	Y	200	155	1	Y (4)	Likely to be impacted
1296	A	Y	170	115	2	N	Likely to be impacted
PA 184							Likely to be impacted
1338	A	Y	165	60	1	Y (1)	Likely to be impacted
1313	A	Y	190	57	1	Y (2)	Likely to be impacted
1047	A	Y	295	50	1	Y (1)	Likely to be impacted
1063	A	Y	202	100	1	Y (5)	Likely to be impacted
1109	A	Y	212	HWM	0	Y (8)	Likely to be impacted
1528	A	200					Likely to be impacted
1119	A	Y	185	10	0	Y (5)	Likely to be impacted
1230	T						Likely to be impacted
1314	A	Y	250	45	1	Y (4)	Likely to be impacted
1330	A	Y	205	100	1	Y (4)	Likely to be impacted
1124	A	Y	435	115	1	N	Likely to be impacted
1077	P	HWM					Likely to be impacted
1288	A	Y	205	HWM	0	Y (2)	Likely to be impacted
1302	A	N		50	1	Y (8)	Likely to be impacted
1225	A	Y	200	255	1	Y (4)	Likely to be impacted
1210	A	Y	313	60	1	Y (1)	Likely to be impacted
1013	A	Y	480	HWM	0	Y (4)	May be impacted
1099	P						May be impacted
1226	A	Y	300	140	1	N	May be impacted
1135	A	N		315	4	N	May be impacted
1056	A	Y	344	100	1	Y (3)	May be impacted
1307	T						May be impacted
1321	A	Y	250	HWM	0	Y (12)	May be impacted

TABLE 4-6 (Concluded)

PC Number	Permit Status	Pier	Pier Length	Cabin to HWM	Elevation	Stilts	DMMP Impacts
1191	A	Y	255	HWM	0	Y (6)	May be impacted
1387	A	Y	143	HWM	0	Y (2)	May be impacted
1496	A	Y	530	131	2	N	May be impacted
1411	A	Y	278	45	1	Y (1)	May be impacted
PA 186							
1065	A	Y	100	10	5	N	No impacts expected
1369	A	Y	170	HWM	0	Y (3)	No impacts expected
1168	A	Y	150	HWM	0	Y (5)	No impacts expected
1333	A	Y	116	30	3	Y (1.5)	No impacts expected
1337	A	Y	120	70	2	N	No impacts expected
1088	A	Y	118	10	2	Y (3)	No impacts expected
PA 195							
1283	A	Y	16	Water	-1.5	Y (4)	May be impacted
1187	A	Y	125	5	0	Y (4)	May be impacted
PA 196							May be impacted
1300	A	Y	216	60	2	Y (3)	May be impacted
1111	A	Y	150	50	1	Y (3)	May be impacted
1108	A	Y	190	15	1	Y (2)	May be impacted
1160	A	Y	200	30	1	Y (1)	May be impacted
1238	A	Y	157	HWM	0	Y (8)	May be impacted
1052	A	Y	225	10	0	Y (1.5)	May be impacted
1352	A	Y	150	100	1	Y (1.5)	May be impacted
1431	A	Y	103	Water	-2	Y (5)	May be impacted
1197	A	Y	196	HWM	0	Y (8)	May be impacted
1062	A	Y	172	55	1	Y (4)	May be impacted
1027	A	Y	130	140	2	Y (1)	May be impacted
1211	A	Y	325	~100	1	Y (3)	May be impacted
1401	A	Y	237	~100	1	N	May be impacted
1607	A	N		~100	1	Y (3)	May be impacted
PA 197							
1008	P						May be impacted
1113	A	Y	168	26	1	Y (1.5)	May be impacted

* Below existing levee
* A = Active, T = Terminated, P = Extended Processing
Y = yes, N = no, HWM = high water mark
All measurements in feet
Source Texas General Land Office (2001)

substantial effect on employment, economic output, value-added, and indirect business taxes within the project area.

Effects on waterborne transportation from the DMMP alternative would be no different than that of the No-Action alternative described above.

4.12.3 Land Use

No effect on land use would be expected from the No-Action alternative over the LOP. As with the current practice, maintenance dredging and placement operations associated with the project would be confined entirely within the waters of the ULM and LLM and along tidal flats within the Land Bridge (Reach 3). Since no placement areas are located within true upland or shoreline areas, no impacts to land use are anticipated from the No-Action alternative.

Because all proposed new and expanded placement areas are located entirely within the waters of the ULM and LLM, the DMMP alternative would not be expected to affect land use as discussed above.

4.12.4 Environmental Justice

The preferred alternative would be situated entirely within Laguna Madre. No land uses would be altered and there would be no changes that would impinge upon the current life styles and habits of the local residents. Any activities that currently take place in the project area would not be affected as a result of the creation of the project; therefore, no change in the quality of life of the local population is expected. Based on this information, the preferred alternative would not create disproportional impact on any segment of the surrounding communities.

4.13 GIWW, CORPUS CHRISTI TO PORT ISABEL REACH TRANSPORTATION ECONOMICS ANALYSIS

4.13.1 Introduction

One of the perceptions that became apparent in public scoping meetings was that the value of the commercial traffic on the GIWW would not offset the cost of maintaining the GIWW in the Laguna Madre. The ICT recommended that the USACE study several alternative modes of transportation to determine if there was a less costly mode to transport commodities to and from the lower laguna area. The USACE funded a study in 1998 to make this determination (see Appendix H for a summary of this study).

Since the alternative transportation mode study was at least four years old, a comparative transportation analysis was performed to augment the study prepared by Texas A&M University (TAMU) entitled "Effect of Closing the GIWW Below Corpus Christi Bay on Expenditures for Transportation Service," dated May 1998.

The TAMU study investigated the existing inland waterway barge mode, as well as alternative modes of transportation. The study concluded that the existing inland waterway barge mode of transportation is the least costly mode of transportation and that continued operation and maintenance of the GIWW below Corpus Christi Bay is the preferred alternative using economic criteria for evaluation.

The analysis presented below was prepared by the USACE, Galveston District, in an effort to provide an up-to-date alternative modes analysis to further supplement the FEIS. The study was conducted utilizing the most current data available. In addition, the analysis compares the alternative modes transportation costs with the preferred dredging plan cost estimate for the GIWW below Corpus Christi. The benefit-to-cost ratio for continuing to maintain the Corpus Christi to Port Isabel portion of the GIWW at 12 feet is estimated using the ratio of the average annual transportation savings for the preferred dredging plan cost for the existing intracoastal route and the average annual operation and maintenance costs associated with this preferred plan project condition.

4.13.2 Alternative Modes Analysis

For this economic analysis, the without-project future is a shift to an alternative transportation mode (the least cost alternative identified below) and the with-project future is the preferred alternative (described in the DMMP). The with-project future transportation costs were calculated based on use of the existing inland waterway barge mode. The transportation cost savings for the with-project future were calculated based on the difference between the inland waterway transportation cost and that for the least cost alternative transportation mode (without-project future). The transportation costs presented in this document were calculated using calendar year 2000 tonnages. The origin and destination of barge-transported trade flows for the Corpus Christi to Port Isabel reach of the GIWW are presented in Table 4-7.

The alternative modes to the inland waterway barge transportation mode (the preferred plan) assessed were rail, intermodal combination of rail and inland waterway barge, and ocean-going barge. The inland waterway barge and the rail costs were calculated using the Reebie cost models, 1st Quarter 2002 prices. The ocean-going barge costs used were compiled by the Institute for Water Resources and escalated to 2002 prices based on current fuel and labor cost increases.

The comparative cost analysis showed that the combination rail and inland waterway barge transportation mode is the least cost alternative of the alternative transportation modes to the existing inland waterway mode. However, the cost associated with using this alternative transportation mode is almost twice as high as the existing inland waterway mode. Table 4-8 displays the comparative costs.

Only 12.5 percent of total tonnage showed that ocean-going barge had a clear cost advantage over rail or the rail/inland waterway combined model. This tonnage consisted of distillate fuel shipments from Corpus Christi to Brownsville. Ocean-going barges produced savings over rail when large parcel sizes were used; however, an investigation to determine whether the relatively large parcels needed to make ocean-going barges cost effective to meet the refinery input needs was not made. Furthermore, for routes where ocean-going barges showed cost savings over rail, the cost savings differential was relatively small. A comparison of the inland water transportation cost for calendar year 2000 tonnage with rail and the least cost mode is presented in Table 4-8.

TABLE 4-7
ORIGIN AND DESTINATION OF BARGE-TRANSPORTED TRADE FLOWS
INVOLVING THE GIWW BELOW CORPUS CHRISTI BAY
FOR MAJOR COMMODITY GROUPS FOR CY2000
(THOUSAND SHORT TONS)

Commodity/ Product	Origin	Destination	Downbound (tons)	Upbound (tons)	Total (tons)	Percent
COAL	Louisiana	Brownsville, TX	3,581		3,581	
TOTAL COAL			3,581	0	3,581	0.2%
CRUDE PETROLEUM	Brownsville, TX	Matagorda, TX		500	500	
	Harlingen, TX	Corpus Christi, TX		53,606	53,606	
	Harlingen, TX	Houston, TX		20,758	20,758	
	Harlingen, TX	Louisiana		6,428	6,428	
	Harlingen, TX	Texas City, TX		7,650	7,650	
	Matagorda, TX	Brownsville, TX	1,200		1,200	
	Louisiana	Brownsville, TX	1,200		1,200	
	Louisiana	Brownsville, TX	6,200		6,200	
TOTAL CRUDE PETROLEUM			8,600	88,942	97,542	4.5%
PETROLEUM PRODUCTS						
Gasoline	Louisiana	Harlingen, TX	13,042		13,042	
	Louisiana	Brownsville, TX	467,831		467,831	
	Louisiana	Harlingen, TX	324,701		324,701	
	Louisiana	Harlingen, TX	6,812		6,812	
	Louisiana	Harlingen, TX	6,476		6,476	
Subtotal, Gasoline			818,862	0	818,862	
Distillate Fuel Oil	Corpus Christi, TX	Brownsville, TX	268,728		268,728	
	Corpus Christi, TX	Harlingen, TX	53,879		53,879	
	Houston, TX	Brownsville, TX	9,800		9,800	
	Texas City, TX	Brownsville, TX	14,844		14,844	
	Brownsville, TX	Corpus Christi, TX	0	1,133	1,133	
Subtotal, Distillate Fuel Oil			347,251	1,133	348,384	
Residual Fuel Oil	Beaumont, TX	Brownsville, TX	2,400		2,400	
	Louisiana	Brownsville, TX	1,200		1,200	
	Corpus Christi, TX	Brownsville, TX	7,087		7,087	
	Corpus Christi, TX	GIWW Corpus/Mexico	863		863	
	Corpus Christi, TX	Harlingen, TX	27,847			
	Houston, TX	Brownsville, TX	277		277	
Subtotal, Residual Fuel Oil			39,674	0	39,674	
Lube Oil & Greases	Beaumont, TX	Brownsville, TX	13,800		13,800	
	Kentucky	Brownsville, TX	2,047		2,047	
	Louisiana	Brownsville, TX	6,541		6,541	
	Galveston, TX	Brownsville, TX	6,600		6,600	
	Houston, TX	Brownsville, TX	57,491		57,491	
	Michigan	Brownsville, TX	4,264		4,264	
	Ohio	Brownsville, TX	25,684		25,684	
	Pennsylvania	Brownsville, TX	3,862		3,862	
	Mississippi	Brownsville, TX	4,332		4,332	
	Arkansas	Brownsville, TX	40,235		40,235	
Subtotal, Lube Oil & Greases			164,856	0	164,856	

TABLE 4-7 (Continued)

Commodity/ Product	Origin	Destination	Downbound (tons)	Upbound (tons)	Total (tons)	Percent
Petro. Jelly & Waxes	Houston, TX	Brownsville, TX	21,776		21,776	
	Brownsville, TX	Houston, TX	0	1,249	1,249	
Subtotal, Petro. Jelly & Waxes			21,776	1,249	23,025	
Naphtha & Solvents	Houston, TX	Brownsville, TX	871		871	
	San Bernard River, TX	Brownsville, TX	9,497		9,497	
Subtotal, Naphtha & Solvents			10,368	0	10,368	
Asphalt, Tar & Pitch	Corpus Christi, TX	Brownsville, TX	13,726		13,726	
Subtotal, Asphalt, Tar & Pitch			13,726	0	13,726	
Petroleum Coke	Louisiana	Brownsville, TX	1,205		1,205	
	Brownsville, TX	Louisiana		800	800	
Subtotal, Petroleum Coke			1,205	800	2,005	
Liquid Natural Gas	Houston, TX	Brownsville, TX	900		900	
Subtotal, Liquid Natural Gas			900		900	
TOTAL PETROLEUM PRODUCTS			1,418,618	3,182	1,421,800	66.1%
CHEMICALS AND RELATED PRODUCTS	Beaumont, TX	Harlingen, TX	1,868		1,868	
	Corpus Christi, TX	Harlingen, TX	10,833		10,833	
	Houston, TX	Harlingen, TX	1,916		1,916	
	Louisiana	Brownsville, TX	6,197		6,197	
	Louisiana	Harlingen, TX	83,680		83,680	
	Mississippi	Harlingen, TX	4,700		4,700	
	Texas City, TX	Harlingen, TX	6,193		6,193	
	Bayport, TX	Brownsville, TX	7,174		7,174	
	Beaumont, TX	Brownsville, TX	8,957		8,957	
	Brownsville, TX	Ohio		1,290	1,290	
TOTAL CHEMICALS AND RELATED PRODUCTS			131,518	1,290	132,808	6.2%
CRUDE MATERIALS, INEDIBLE EXCEPT FUELS						
Sand and Gravel	Victoria, TX	Harlingen, TX	75,000		75,000	
	Houston, TX	Brownsville, TX	1,367		1,367	
	Louisiana	Brownsville, TX	3,814		3,814	
Subtotal, Sand and Gravel			80,181	0	80,181	
All Other Crude Materials	Louisiana	Brownsville, TX	6,387		6,387	
	Ohio	Brownsville, TX	1,304		1,304	
	Illinois	Brownsville, TX	5,780		5,780	
	Tennessee	Brownsville, TX	1,624		1,624	
	Brownsville, TX	Tennessee		19,083	19,083	
	Brownsville, TX	Beaumont, TX		1,400	1,400	
	Brownsville, TX	Minnesota		2,654	2,654	
Subtotal, All Other Crude Materials			15,095	23,137	38,232	
TOTAL CRUDE MATERIALS, INEDIBLE EXCEPT FUELS			95,276	23,137	118,413	5.5%

TABLE 4-7 (Concluded)

Commodity/ Product	Origin	Destination	Downbound (tons)	Upbound (tons)	Total (tons)	Percent
PRIMARY MANUFACTURED GOODS						
Primary Iron and Steel Prdcts.	Louisiana	Brownsville, TX	30,312		30,312	
	Illinois	Brownsville, TX	3,541		3,541	
	Pennsylvania	Brownsville, TX	78,474		78,474	
	Ohio	Brownsville, TX	24,411		24,411	
	Brownsville, TX	Arkansas		1,400	1,400	
	Brownsville, TX	Illinois		32,152	32,152	
	Brownsville, TX	Tennessee		25,716	25,716	
	Brownsville, TX	Houston, TX		4,550	4,550	
	Brownsville, TX	Ohio		15,537	15,537	
	Brownsville, TX	Minnesota		11,110	11,110	
	Brownsville, TX	Pennsylvania		3,152	3,152	
Subtotal, Primary Iron and Steel Products			136,738	93,617	230,355	
Lime, Cement and Glass	Houston, TX	Harlingen, TX	6,216		6,216	
	Pennsylvania	Brownsville, TX	4,239		4,239	
Subtotal, Lime, Cement and Glass			10,455	0	10,455	
Primary Non-Ferrous	Louisiana	Brownsville, TX	12,628		12,628	
Metal Products	Ohio	Brownsville, TX	1,230		1,230	
Subtotal, Non-Ferrous Metal Products			13,858	0	13,858	
TOTAL PRIMARY MANUFACTURED GOODS			161,051	93,617	254,668	11.8%
FOOD & FARM PRODUCTS	Louisiana	Brownsville, TX	18,930		18,930	
	Harlingen	Louisiana		101,550	101,550	
TOTAL FOOD AND FARM PRODUCTS			18,930	101,550	120,480	5.6%
ALL MANUFACTURED EQUIPMENT, MACHINERY AND PRODUCTS						
	Corpus Christi, TX	Harlingen, TX	3		3	
	Louisiana	Brownsville, TX	2,934		2,934	
	North Carolina	Brownsville, TX	348*		348*	
TOTAL ALL MANUFACTURED EQUIPMENT, MACHINERY AND PRODUCTS			2,937	0	2,937	0.1%
GRAND TOTAL			1,840,511	311,718	2,152,229	100%

* Excluded from calculations

TABLE 4-8

ANNUAL TRANSPORTATION SAVINGS
(CY2002 PRICE LEVELS)

Mode	Annual Transportation Cost	Annual Transportation Savings
Inland Waterway Barge	$19,598,000	
Least Cost Alternative (Combination Rail/Inland Waterway Barge)	$37,696,000	$18,098,000
Rail	$51,381,000	$31,783,000

Note: The savings represent increments between the existing inland waterway barge mode and the identified alternative.

The per ton transportation costs were calculated on a commodity specific basis using the specific Standard Industrial Trade Classification (SITC) Revision 3 and Transportation Commodity Classification (TCC) commodity codes.

Comparison of rail with the combined rail, inland waterway mode (least cost transportation alternative) indicated that there were clear savings from using rail for short distance and inland waterway barges for the longer leg of the trip. Instead of using rail as the exclusive alternative, rail was used between Brownsville and Harlingen and the tonnage was transferred to inland waterway barge for the remainder of the trip. The transportation cost for the combined alternative reflected the inclusion of the necessary additional terminal costs.

Barge cost comparisons were made using empty backhaul rates of 50 and 100 percent and comparisons were also made using both "general" and "dedicated" tow types in order to identify the least cost scenario. It is recognized that regular shipment costs have "contract rates" and would, therefore, fall under the classification of "dedicated." In addition, empty backhauls are characteristic of many of the specialized petroleum and chemical products transported through the project reach.

A comparison of the tow type and backhaul variables was made for 100 percent of the total tonnage. This analysis was evaluated for the inland waterway barge mode. The analysis showed that the general tows with a 50 percent empty backhaul rate were the least cost option 99.0 percent of the time.

Another comparison of the tow type and backhaul variables was made for 39 percent of total tonnage. This segment was evaluated for the combined rail, inland waterway mode. This analysis showed that the general tows with a 50 percent empty backhaul rate were the least cost option 99.8 percent of the time.

The annual cost for dedicated tows, even with a 50 percent empty backhaul rate, was $42.0 million. The annual costs for general tows, with 100 percent empty backhauls, was $22.6 million. Economic theory suggests that costs will gravitate toward the least cost method in the long run. Given the results of this sensitivity analysis, the variables for tow type "general" and backhaul rate "50 percent empty" were chosen as the least cost mode analysis for the combination rail and inland waterway barge. As presented in Table 4-8, the annual cost for this base (preferred plan) condition is $19.6 million. The table also displays the comparison of the transportation cost for the base condition and the alternative transportation modes that would be used if the existing inland waterway mode was not available. These savings represent the difference in transportation costs for the existing 12-foot channel when compared to the alternate transportation modes.

4.13.3 Maintenance Cost and Benefits Analysis

A dredging cost estimate for the preferred dredging and placement plan as described in the DMMP was prepared and provided under contract with Moffatt & Nichol. These costs along with the annual transportation cost savings compared to the least cost transportation alternative from Table 4-8 were used to calculate a benefit to cost ratio. If this ratio is greater than 1.0, then the additional cost for maintaining the GIWW in the DMMP when compared to the savings over the least cost transportation alternative will be justified.

Before a comparison of costs and benefits can be made over the 50-year life of the project, each value (benefits or costs) is calculated over the project life and discounted back to present worth using the Federal discount rate. The average annual transportation savings and costs were calculated utilizing the current Federal discount rate of 5.875 percent and an annual growth rate of 1.3 percent annually was used for traffic growth over the project life. The annual growth rate was based on current Inland Waterway Review growth rates. Average annual transportation cost savings, average annual maintenance costs, and associated benefit-cost ratios are shown in Table 4-9.

TABLE 4-9

AVERAGE ANNUAL BENEFITS AND MAINTENANCE COSTS,
AND BENEFIT-TO-COST RATIOS
(THOUSANDS OF DOLLARS)

Scenario	Average Annual Benefits	Average Annual Costs	Net Benefits	B/C Ratio
Benefits start first year of project life	$22,378	$7,610	$14,768	2.9
Benefits start after 5 years of channel shoaling	$18,151	$7,610	$10,541	2.4

Because the shipping industry may not shift to an alternate mode immediately, two calculations for benefits were made. One was based on the industry shifting to the least cost transportation mode immediately, which would provide the highest benefits for the preferred DMMP plan since it is less costly. The other, perhaps more realistic, calculation was based on the industry using the GIWW for five years until it shoaled enough to prevent efficient use of the section of GIWW that would be covered by rail in the least cost transportation alternative. The savings attributable to the preferred DMMP plan would be lower in this scenario since the shift would occur later in the project life.

4.13.4 Summary

A comparative transportation analysis was performed to provide an update to the original analysis prepared in 1998 by Texas A&M University. The results of this updated analysis support the TAMU study. Both studies conclude that an alternate transportation mode for the GIWW below Corpus Christi would significantly increase the total transportation costs associated with current commodity/product flows on the waterway. The TAMU study estimates a doubling (or 100 percent increase) in transportation costs, while this study estimates approximately 90 percent increase.

Further comparisons were made with a January 2002 study prepared by Foster Wheeler Environmental Corporation for the Gulf Intracoastal Canal Association. The Foster Wheeler study results confirmed the TAMU estimate of 100 percent increase in transportation costs with shifting commodities to alternate transportation modes for the Corpus Christi to Port Isabel reach of the GIWW.

For the current analysis, a comparison between the costs and benefits was made. However, for both the TAMU and Foster Wheeler studies, cost estimates were unavailable. For the current analysis, two different timing scenarios were investigated: benefits starting in the first year of project life, and benefits starting in year 5 of project life. Under both scenarios, the benefit-cost ratios exceed 2.0, indicating project justification. Shifting transportation modes on the Corpus Christi to Port Isabel reach of the GIWW would result in the loss of over $18 million in annual transportation savings.

4.14 CUMULATIVE IMPACTS

4.14.1 Introduction

Cumulative impact has been defined by the President's Council on Environmental Quality (CEQ) as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such action." Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. Impacts include both direct effects, which are caused by an action and occur at the same time and place as the action, and indirect effects, which are also caused by the action and occur later in time and are farther removed in distance, but which are still reasonably foreseeable. Ecological effects refer to effects on natural resources and on the components, structures, and functioning of affected ecosystems, whether direct, indirect, or cumulative.

In assessing cumulative impact, consideration is given to (1) the degree to which the DMMP alternative affects public health or safety, (2) unique characteristics of the geographic area, (3) the degree to which the effects on the quality of the human environment are likely to be highly controversial, (4) the degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks, and (5) whether the action is related to other actions with individually insignificant, but cumulatively significant, impacts on the environment.

Cumulative effects can result from many different activities including the addition of materials to the environment from multiple sources; repeated removal of materials, ecosystem components, or organisms from the environment; and repeated environmental changes over large areas and long periods. More complicated cumulative effects occur when stresses of different types combine to produce a single effect or suite of effects. Large, contiguous habitats can be fragmented, making it difficult for organisms to locate and maintain populations between disjunctive habitat fragments. Cumulative impacts may also occur when the timings of perturbations are so close that the effects of one are not dissipated before the next occurs, or when the timings of perturbations are so close in space that their effects overlap.

Three projects were identified as pertinent to the future condition of Laguna Madre and the surrounding area. Parameters to be addressed include biological, physical, chemical, socioeconomic, and cultural attributes. The methodology used to analyze these projects for their cumulative effect on the Laguna Madre project area is described below.

4.14.2 Cumulative Impact Assessment Methodology

Projects evaluated in the DMMP alternative assessment include the following:

- Reasonably foreseeable future actions:
  - Packery Channel
  - JFK Causeway
  - BNP Exploration
- Past or present actions:
  - Brownsville Ship Channel
  - Port Mansfield Ship Channel Maintenance Dredging and Placement

The study area for the cumulative impact assessment was delimited by the northernmost reaches of the ULM in Nueces County to the southernmost reaches of the waters of the LLM within Cameron County.

Direct impacts that could be quantified in acreage were considered for habitat assessment when information was available. Habitats for cumulative impact assessment were identified from reports developed for the above proposed projects and include SAV, wetlands, estuarine sand flats/mud flats/algal mats, open-water, reef habitat, coastal shore areas/beaches/sand dunes. In addition to habitats, impacts to specific resource categories were addressed in a more qualitative manner based on information provided in documents reviewed for each project. These were described as biological attributes (bay bottom habitat, terrestrial habitat, plankton, benthos, finfish, shellfish, mammals, reptiles/amphibians, threatened and endangered species, and EFH), physical environment (air quality/noise, topography/bathymetry, sediment quality, water quality, freshwater inflow, circulation, and tides), and cultural/socioeconomic attributes (recreation, commercial and recreational fisheries, ship accidents/spills, oil/gas production on submerged lands, cultural resources, public health, safety, and parks/beaches).

4.14.3 Evaluation Criteria

Cumulative effects were determined by reviewing impacts as described in the project documents and determined from recent habitat information obtained from Section 4. Impact acreage of each habitat in the study was determined from this assessment, if available.

4.14.3.1 Individual Project Evaluation

Individual project documents were reviewed for impacts to selected habitats based on the evaluation criteria described above. The USACE assumed the validity of these reports and did not update published documents, nor were the disposal practices proposed in reviewed documents verified for current ongoing projects. In addition, no field data were collected to verify project impacts described in reviewed documents. This analysis recognizes that some of the projects assessed are undergoing revisions that may alter their environmental impact. Necessarily, this analysis relied only on existing published documents. If acreage was available, it was summed for each habitat to obtain a cumulative acreage impact. It should be noted that because of the diverse mix of documents that were reviewed for cumulative impacts and because of the fact that not all documents used the same definitions or even the same categories of resources, it was sometimes necessary to lump or modify categories so that the quantities in this section may not be exactly comparable with those presented in sections 3 and 4 of this EIS. However, every attempt has been made to make this section internally consistent, so that all projects included in Cumulative Impacts are evaluated comparably.

4.14.3.2 Resource Impact Evaluation

Biological/ecological, physical/chemical, and cultural/socioeconomic resource impacts were evaluated based on individual project reviews. In Table 4-10, a quantitative assessment of biological/ecological resources was prepared. A qualitative discussion of biological/ecological, physical/ chemical resources, and cultural/socioeconomic resources were presented using information published in reviewed documents. The following is a brief description of the evaluated projects.

4.14.4 Reasonably Foreseeable Future Actions

4.14.4.1 Packery Channel

Packery Channel is an environmental enhancement project that will provide a dredged channel across Padre Island between the ULM and the Gulf of Mexico, just north of the project area for this FEIS. The channel is located roughly north-northeast of the JFK Causeway, which crosses the Laguna Madre between the City of Corpus Christi and North Padre Island. The existing channel is largely the result of the modern dredging of a historically shallow cut between the historical pass and Laguna Madre. The total length of the proposed channel from the Gulf end of the jetties to the GIWW would be approximately 18,500 feet (3.5 miles). The alignment would not be straight, but would follow an existing channel from the Laguna Madre for approximately 2.6 miles, then a new channel would extend east-southeast an additional 0.9 mile to the Gulf.

TABLE 4-10

CUMULATIVE IMPACTS[1]

Project	DMMP Maintenance of the GIWW, Laguna Madre	Packery Channel[2]	Raising Kennedy Causeway	BNP Petroleum Corporation	Mansfield Ship Channel	Brownsville Ship Channel	Permit Actions	Total
RESOURCE IMPACTS								
Topography/Bathymetry	115.9 miles	3.5 miles	0.9 miles	2.3 miles	9.5 miles	18.4 miles	NA	151 miles
Shore/Beach/Dunes	NI	61 ac	NI	NA	NA	NA	NA	61 ac
Salt Marsh/Mangrove Swamp	NA	17.8 ac	11.5 ac	NA	NA	58.6 ac	NA	87.9 ac
Flats	88 ac	1.9 ac	NI	NA	NA	56.0 ac	3.1 ac	149.0 ac
Open Water	4,887[3]	7.1 ac	NI	8.4 ac	NA	NI	NA	4,902.5 ac
Oyster Reef	NI	NI	NI	NA	NI	NA	NA	
Shallow Bay Bottom Habitat (0 to –12 MLT)	4,887[4]	33.3 ac	NI	25 ac	NA	37.6 ac	NA	4,982.9 ac
Gulf of Mexico Bottom Habitat	NI	69.1 ac	NI	NA	358 ac	1,168 ac	NA	1,595.1 ac
Terrestrial Habitat	5,424[4]	42.2 ac	NI	NA	NA	618 ac	NA	6,084.2 ac
Submerged Aquatic Vegetation (SAV)	3,477[4]	5.4 ac	NI	NA	NA	NA	56.3 ac	3,538.7 ac
Essential Fish Habitat (subtotal of salt marsh, flats, shallow bay bottom habitat, and SAV)	8,452[4]	58.4 ac	11.5 ac	16.6 ac	NA	81.7 ac	NA	8,620.2 ac
MITIGATION/BENEFITS								
Upland Habitat	NI	NI	NI	4.2 ac	NA	NA	NA	4.2 ac
Bay Bottom Habitat	NI	NI	5 ac	NA	NA	500.2 ac	NA	505.2 ac
Shallow-Water Habitat	NI	NI	11 ac	4.2 ac	NA	NA	NA	16.2 ac
Submerged Aquatic Vegetation	NI	16.2 ac[5]	NI	NA	NA	NA	104.7 ac	120.9 ac
Wetlands (salt marsh, brackish, fresh)	NI	18	NI	1.3 ac	NA	NA	NA	19.3 ac
Flats	NI	NI	NI	NA	NA	NA	5.5 ac	5.5 ac
Beach Nourishment	NI	91.3 ac	NI	NA	NA	NI	NA	91.3 ac
Dune Mitigation	NI	1.5 ac	NI	NA	NA	NI	NA	1.5 ac
SOCIOECONOMICS								
Environmental Justice	NI	NI	NI	NA	NA	NA	NA	
Community Cohesion	NI	NI	NI	NA	NA	NA	NA	
Relocations	NI	NI	1 business	NA	NA	NA	NA	1 business
Demand for Housing Units	NI	3,150	NA	NA	NA	NA	NA	3,150
Population Increase	NI	5,200	NA	NA	NA	NA	NA	5,200

TABLE 4-10 (Concluded)

Project	DMMP Maintenance of the GIWW, Laguna Madre	Packery Channel[2]	Raising Kennedy Causeway	BNP Petroleum Corporation	Mansfield Ship Channel	Brownsville Ship Channel	Permit Actions	Total
BENEFITS								
Temporary (Construction Phase)								
Employment (avg. annual)	NI	350	1,700	NA	NA	361	NA	2,411
Wages (avg. annual)	NI	NA	$26.9 M	NA	NA	NA	NA	$26.9 M
Total Output (avg. annual)	NI	NA	$114.3 M	NA	NA	NA	NA	$114 M
Indirect Business Tax Impact (avg. annual)	NI	NA	NA	NA	NA	NA	NA	
Permanent								
Employment (avg. annual)	NI	2,500	NI	NA	NA	183	NA	2,683
Wages (avg. annual)	NI	$220 M	NI	NA	NA	NA	NA	$220 M
Total Output (avg. annual)	NI	NA	NI	NA	NA	NA	NA	
Indirect Business Tax Impact (avg. annual)	NI	NA	NI	NA	NA	NA	NA	

NI = No impacts; NA = Not Available; M = million (dollars).

1 It should be noted that mitigation for project impacts, which are included in some of these acreages, does not constitute a net benefit to the system.

2 Mitigation acreages for Packery Channel will be located at Shamrock Island in Corpus Christi Bay, which is outside the project area.

3 Based on Shallow Bay Bottom Habitat.

4 These values are 115 ac more for Shallow Bay Bottom, 213 ac less for Terrestrial, 1,362 ac less for SAV, and 1,460 ac less for EFH than the No-Action alternative.

5 Corpus Christi Bay, not the Laguna Madre.

Approximately 810,000 cy of material would be dredged. The new work material would be located in four placement areas: (1) 128,800 cy on the south side of the channel between the existing seawall and the proposed shoreline protection bulkhead (approximately 2,500 linear feet); (2) 76,000 cy on the north side of the channel to the north of the proposed shoreline protection bulkhead (approximately 3,600 linear feet); (3) 60,400 cy on the south side of the channel between the existing seawall and the proposed shoreline protection bulkhead (approximately 900 linear feet) and west of PA 1; (4) 544,800 cy on the beach in front of the seawall on North Padre Island (approximately 6,000 linear feet). A sand transfer system would be utilized to move sand from the areas north and south of the jetties to designated beach areas. Amenities will include the construction of navigational aids, roadways, parking areas, walkways, and two recreational areas (USACE, 2003).

4.14.4.2 John F. Kennedy Causeway

The JFK Causeway is located in southeast Nueces County in the City of Corpus Christi on the northern end of the Laguna Madre providing a connection between the mainland and North Padre Island. The current causeway is approximately 4 feet MSL with a 3,280-foot-long bridge, which provides a clear roadway width of 54 feet, including a divided four-lane road with a concrete median barrier and a vertical clearance of 80 feet above the water surface.

The proposed project would raise the existing JFK Causeway (Park Road 22) to a minimum of 9 feet above MSL from O'Connell Street on the mainland to a point 1,740 feet east of Aquarius Drive on Padre Island. The new portion of the bridge would be 2,850 feet with a 2,550-foot water opening at the west end of the causeway. No new through lanes would be added by the project, and the existing two lanes in each direction would remain upon completion of the project. Between O'Connell Street and the Laguna Madre, the existing four-lane divided highway would be converted to an urban freeway with four main lanes and frontage roads to provide access to abutting properties. A turnaround at the western bank of the Laguna Madre would aid local traffic access. During construction, one lane in each direction would remain open to traffic. The westbound traffic lanes would be completed first to ensure safe evacuation in case of an emergency during construction. The GIWW high bridge would not be modified as part of this project since it is already well above the 9-foot minimum elevation needed for safe evacuation during storm events. (Hicks et al., 1999)

4.14.4.3 BNP Petroleum Corporation

BNP Petroleum Corporation applied for a USACE Permit (Permit Application 22754, Public Notice issued 8/27/02) to "install, operate, and maintain structures and equipment necessary for oil and gas drilling, production, and transportation activities" at a site roughly 2,700 feet east of PA 197 and 2,400 feet west of the Congressionally authorized boundary of PINS. A channel 12,110 feet long, 60 feet wide at the bottom, and –7 feet MLT was to have accessed the site from the GIWW, between PAs 197 and 198. The dredged material from the channel was to be used to construct a roughly 14-acre armored beneficial use site, roughly 30 percent of which was to be upland habitat, planted with trees; the area between the trees and another 10 percent was to be planted with salt marsh species, 30 percent was to be sand flats, and the remaining 30 percent was to be shallow-water habitat. However, just before this

FEIS was released, BNP withdrew the permit application and is in the process of developing conceptual alternative dredged material placement plans.

4.14.5 Past Or Present Actions

There has been an enormous effort by the petroleum industry to explore and produce hydrocarbons in the Laguna Madre since the 1930s. An effort was made to compile this information by searching the microfiche files in the Regulatory Division, Galveston District, USACE to document the number of permits, whether they were used, and the impacts and mitigation efforts that resulted. All records of permits issued from 1937 to 2002 were pulled and checked to determine if any activities were recorded under the permit. If there was no action recorded (no exploration, drilling and production, or other activity), the record was deleted from further consideration. The remaining 323 records then were reviewed for information on impacts and mitigation and the results recorded in the last column of Table 4-10. This information is not presented as complete and accurate since few details were recorded, especially prior to passage of NEPA in 1969. It is presented as general information only and should not be used in any meaningful analysis of past impacts in the Laguna Madre.

4.14.5.1 Deepwater Channel and Multipurpose Terminal Construction and Operation Near Brownsville, Texas

The Brownsville Ship Channel is located at the extreme southern tip of Texas in the area known locally as the Lower Rio Grande Valley. This area includes portions of Cameron, Hidalgo, Willacy, and Starr counties that are adjacent to or near the Mexican states of Tamaulipas and Nuevo Leon. The Port of Brownsville provides the closest modern and deep draft port facilities for the industrial and agricultural production of the Lower Rio Grande Valley and the industrial and consumer areas of Matamoros, Mexico, approximately 6 miles west of the port. This strategic position along the Gulf of Mexico has helped stimulate industrial growth.

This deepwater port project involved deepening and widening the existing ship channel into the Port of Brownsville to accommodate design vessels of 110,000 deadweight tons (DWT) and 44,000 DWT in various portions of the channel. Proposed multipurpose docks at a deepwater turning basin now provide liquid and dry-bulk offloading capabilities. Onshore support facilities include a crude oil tank farm, ore and grain terminal, a wastewater treatment facility, a warehouse and office buildings, and two transportation corridors. Since this project was constructed in the early 1980s, many mitigation measures now commonplace were not practiced at the time, hence loss of habitat may have been higher than included in the revised EIS. Moreover, many potential and/or actual impacts to parameters addressed in more recent studies were not evaluated at the time.

4.14.5.2 Port Mansfield Maintenance Dredging and Disposal

The Willacy County Navigation District dredged the Port Mansfield Channel from the GIWW at Port Mansfield, Texas, eastward through the Laguna Madre and Padre Island to the Gulf of Mexico in 1957. Since that time, historical maintenance of the entrance channel by hopper dredge has resulted in dredged material being placed in contained and noncontained disposal areas along the channel.

4.14.6 Results

4.14.6.1 Ecological/Biological Resources

Biological and ecological resources would experience a minor, temporary net negative impact from increased turbidity associated with the dredging and dredged material placement required in the majority of the projects evaluated. Temporary disturbance of bay bottom due to open-bay placement and channel dredging would be anticipated to provide temporary negative impacts to benthos and SAV. Loss of freshwater marsh and upland habitat due to construction would be expected to reduce food and nutrient sources, although not all projects would impact these habitat types. Birds could benefit by the periodic placement of dredged material on existing upland sites due to creation of temporary unvegetated nesting substrate provided that a land bridge is not created that would allow for the migration or invasion of predatory species such as coyotes and raccoons. However, construction and placement operations associated with almost all evaluated projects could disturb nesting activity as well as some nesting habitat. Mammals, reptiles/amphibians, and terrestrial vegetation would be negatively impacted, temporarily, by placement of material on existing upland placement sites. Impacts to waterfowl species from open-bay placement would primarily be limited to areas where material would be placed directly in SAV, which provide foraging habitat for many waterfowl species. Increased turbidity, as result of material placement could also have a negative indirect effect on SAV and thus waterfowl foraging habitat. However, as discussed previously, the DMMP alternative would result in an area-wide increase in SAV, thus potentially enhancing waterfowl foraging habitat. Threatened/endangered species may be temporarily negatively affected if they are displaced by single-event or periodic construction/dredging or placement. Some benefit, however, may be realized from creation of marsh and unvegetated nesting substrate on existing placement sites. Although wetland vegetation would be negatively impacted where wetlands are damaged or destroyed by project construction, marsh creation projects associated with beneficial uses of dredged material in some of the reviewed projects would benefit wetland vegetation, resulting in an overall positive cumulative impact in the general study area.

Wetlands

Wetlands evaluated included salt marsh (high and low) and mangrove swamps. The DMMP alternative would not impact any mangrove swamps, though some unquantified salt marsh wetlands will occur. Negative impacts to wetland habitat are/were expected from the Packery Channel project include 17.8 acres of salt marsh; JFK Causeway (11.5 acres of salt marsh), and the Brownsville Ship Channel (44.1 acres of salt marsh and 14.5 acres of mangrove swamp) projects. Mitigation for negative impacts associated with these projects includes 18 acres for the Packery Channel project. A beneficial use site will be constructed for the BNP project and approximately 1.3 acres of salt marsh will be created in addition to uplands, sand flats, and shallow-water habitat.

Finfish/Shellfish

Shallow water nurseries and spawning grounds are sensitive sites within the general project area. Shrimp and finfish would be temporarily displaced due to dredging activity and open-water placement of dredged material, and periodic loss of production would occur during maintenance dredging. These areas would recover after activity has ceased, but the quality of the habitat would be reduced by repeated placement of dredged material. Dredging and placement activity would increase turbidity, which may impede gill function in finfish and shrimp not able to leave the area. Damage to marshes or seagrasses from placement of dredged material would reduce nursery areas available for finfish and shrimp. These impacts are associated with all dredging projects reviewed, as well as the DMMP alternative. Shallow bay bottom habitat (0 to –12 ft MLT) would be/has been impacted by the following projects: Packery Channel (33.3 acres), JFK Causeway (no impact), Brownsville Ship Channel (37.6 acres), and BNP (25 acres). The DMMP alternative would impact a maximum of 4,887 acres of shallow bay bottom (0 to –12 ft MLT), excluding the GIWW, 115 acres more than the No-Action alternative, primarily because of placement into deeper water to avoid seagrass impacts. Approximately 11 acres for the JFK Causeway project and 4.2 acres for the BNP project would be created. Newly created acreage for the Brownsville Ship Channel expansion was not available.

The Packery Channel project would also negatively affect approximately 69.1 acres of Gulf of Mexico ocean bottom though the majority of this is a temporary impact from sand placement for beach nourishment. The effects from the Brownsville Ship Channel expansion on ocean bottom habitat were not reported.

Terrestrial Habitat

Terrestrial vegetation present on any placement sites would be covered by deposition of the maintenance materials as a result of those reviewed projects requiring dredging activities. This vegetation consists mainly of opportunistic species that thrive on disturbed soils and are likely to return after the site has been dewatered. These assemblages are not considered significant contributors as food or detritus sources. Packery Channel would result in a loss of 42.2 acres, while the DMMP alternative would disturb a maximum of 5,424 acres, 213 acres less than the No-Action alternative. Although terrestrial vegetation found in the vicinity of the JFK Causeway would be lost during construction of the elevated bridge, the upland areas within the road ROW would continue to provide habitat for opportunistic species. The Brownsville Ship Channel expansion resulted in the loss of 618.0 acres. Cumulatively, these projects have resulted in impacts to approximately 6,084 acres.

Projects providing mitigation for upland habitat include a proposal of dune mitigation for 5,670 cy (1.5 acres) of displaced dunes for restoring and revegetating portions of the Packery Channel project. Newly created terrestrial habitat for Brownsville Ship Channel and Port Mansfield, if any, was not reported. The BNP project will create approximately 4.2 acres to be planted with trees at a beneficial use site.

Impacts to waterfowl species from open-bay placement would primarily be limited to areas where material would be placed directly in SAV, which provide foraging habitat for many waterfowl species. Increased turbidity, as result of material placement could also have a negative indirect effect on SAV and thus waterfowl foraging habitat. However, as discussed previously, the DMMP alternative would result in an area-wide increase in SAV, thus potentially enhancing waterfowl foraging habitat. Another impact would be on those PAs which would be expanded and, thus, potentially could molest or destroy breeding shorebirds. However, the DMMP will also increase the size of channels and, thus, the isolation from predators at other PAs. Quantification of either the negative or beneficial impacts is not possible.

Terrestrial Wildlife

The general project area is not considered high quality wildlife habitat, except for some bird species. Most terrestrial species would be negatively affected by the periodic placement of dredged material on upland disposal sites and construction of facilities and roads associated with the projects. Upland and emergent dredged material placement areas would be periodically covered, resulting in the death of any slow moving or nonmotile species. Larger, more mobile species, especially birds, would be temporarily displaced; however the habitat would likely return following dewatering of upland disposal sites. Under the DMMP alternative, several PAs would be managed specifically for bird habitat.

Impacts to waterfowl species and habitats would occur primarily as a result of habitat modification. Dredging and placement activities, particularly open-bay placement of dredged material, could have an adverse effect on seagrasses as a result of increased turbidity and modification of the habitat. Seagrasses provide the primary food source for many species of wintering waterfowl including redheads and northern pintails. However, based on document reviews, SAV would experience an area-wide increase under the DMMP alternative and would therefore result in an increase in waterfowl foraging habitat. A maximum of 3,477 acres of SAV would be negatively impacted by the DMMP alternative, which is 1,307 fewer than the 4,784 acres of SAV negatively impacted by the No-Action alternative.

Threatened and Endangered Species

Refer to Section 4.7 in this FEIS for a discussion of potential impacts to threatened and endangered species from the DMMP alternative. No significant impacts to threatened or endangered species are anticipated as a result of the reviewed projects in the general project area. A nonjeopardy Biological Opinion for impacts to endangered and threatened species relative to Packery Channel has been issued by FWS. Piping plover critical habitat would be affected by the dredging of Packery Channel resulting in approximately 1.5 acres of critical habitat lost due to the construction of the channel and jetties. In addition, 20.0 acres of beach nourishment would be placed on foraging beachfront areas for the piping plover, yet this would be considered a temporary impact. Port Mansfield Channel dredging did not significantly impact threatened and/or endangered species, particularly piping plovers, a species surveyed in the area for many years. Wildlife surveys indicated that most if not all impacts would be temporary during dredging and that provisions for proper site disposal would prevent long-term impacts to sensitive species. Maintenance dredging of the Port Mansfield Channel is covered under a Biological Opinion, with Reasonable and Prudent Measures for monitoring. The Brownsville Ship Channel data did not indicate any definite plan for beach or shoreline nourishment although it stated that such mitigation was being considered at the time the report was written.

Benthic Habitat

Benthic habitat on the open-bay bottom would be temporarily affected by the project due to excavation and placement of dredged materials. Benthic habitat would be impacted, temporarily, as a result of the sand placement onto Gulf of Mexico ocean bottom that would occur following the opening of Packery Channel (69.1 acres). Dredging activity in association with the reviewed projects may temporarily reduce the quality of nearby benthic habitat from increased turbidity. Most organisms present in areas covered for open-water placement sites would be permanently lost; however, recovery would occur after placement is completed. Recent studies in Corpus Christi Bay (Ray and Clarke, 1999) have indicated that recovery of benthic habitat occurs at open-bay placement sites in less than 1 year. Opportunistic populations can overtake newly created benthic habitat increasing its value to foraging species.

Petroleum products may be present in roadway runoff, which negatively affects the benthos in the immediate vicinity of the JFK Causeway. Piers constructed to support the causeway and bridge are expected to be colonized by animals such as barnacles, oysters, and limpets, providing habitat for crabs, shrimp, small fish, and other marine organisms. The creation of shallow-water unvegetated and vegetated habitat would be expected to provide rich substrate for benthic populations to develop. Rock breakwaters associated with beneficial use sites and the jetties at Packery Channel are expected to be colonized by animals such as barnacles, oysters, and limpets, providing habitat for crabs, shrimp, small fish, and other marine organisms.

Port Mansfield and Brownsville Ship Channel projects did not quantify benthic habitat losses. The BNP project includes a loss of 8.4 acres of open-water habitat. Shallow-bay bottom loss is presented under the previous Finfish/Shellfish section.

Plankton

Increased turbidity (Section 4.2.3 and 4.5.2) during dredging and placement would decrease light transmittance necessary for photosynthesis of phytoplankton but may also provide necessary nutrients. Increased turbidity may also negatively affect zooplankton by damaging their filtering mechanism and impeding respiration. However, these impacts are temporary and local. Potential petroleum products released during dredging of the projects, construction of the JFK Causeway, or traffic accidents on the bridge or in the water may have an adverse effect on plankton populations. However, data are not available to provide a quantitative analysis of any potential problems.

Essential Fish Habitat

Section 305(b)(1)(A and B) of the Magnuson Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act, 16 U.S.C. 1801 et seq.), as amended, requires that the Regional Fishery Management Councils submit, by October 11, 1998, amendments to their Fishery Management Plans that identify and describe EFH for species under management. The Act also requires identification of adverse impacts on EFH and the actions that should be considered to ensure that EFH is conserved and enhanced.

Based on direct impacts to SAV, salt marsh, shallow bay bottom habitat, and flats identified in the reviewed projects, impacts to EFH were estimated as follows: Packery Channel (58.4 acres), JFK Causeway (11.5 acres), Brownsville Ship Channel (81.7 acres), and the BNP project (16.6 acres). These four projects would provide mitigation for 540.7 acres. The DMMP alternative (4,887 acres of open-bay bottom and 3,477 acres of SAV with 115 acres more of open-bay bottom and 1,307 acres less of SAV than the No-Action alternative) would disturb the greatest degree of EFH.

Given the size of the Laguna Madre system (370,650 acres [Teeter et al., 2003]), and the mitigative efforts associated with these projects, impacts to EFH would be minimized.

Submerged Aquatic Vegetation (SAV)

According to studies by Pulich et al. (1997), general trends in the Laguna Madre have shown that seagrass dynamics are highly variable with localized changes. Based on the document reviews, SAV would experience an area-wide increase. A maximum of 3,477 acres of SAV would be negatively impacted by the DMMP alternative, 1,307 fewer than the No-Action alternative since the ICT worked to avoid such impacts when creating the DMMP. The Packery Channel project reports a loss of 5.4 acres of SAV in the new channel; however, mitigation of 16.2 acres has been proposed for an area near Shamrock Island in Corpus Christi Bay located outside the Laguna Madre.

Estuarine Sand Flats/Mud Flats/Algal Flats

The DMMP would impact approximately 88 acres of tidal flats and mud flats (49 fewer than with the No-Action alternative), primarily in the expanded PA 195. This part of the DMMP, however, would not differ from the current practice in that Reach. The Packery Channel project identifies 1.9 acres and the Brownsville Ship Channel identified 56.0 acres of sand or mud flats potentially displaced. Dredged material placed on the Port Mansfield Channel PAs flows onto tidal flats, but this was not quantified.

Open-Water Habitat

The construction of Packery Channel would cause the loss of approximately 7.1 acres of open-water habitat for jetty construction. Levee construction would result in some loss of open-water habitat from the DMMP alternative, but this is not quantifiable. Open-bay bottom habitat loss was quantified and is given above. The BNP project will negatively affect approximately 8.4 acres of open water. No data regarding open-water habitat was available for the other projects under review.

Oyster Reef Habitat

No impacts to oyster reef habitat would result from the DMMP alternative. Impacts to oyster reef habitat were not indicated by any of the reviewed projects.

Coastal Shore Areas/Beaches/Sand Dunes

No significant impacts are expected from the DMMP alternative. Direct impacts to coastal shore areas/beaches/sand dunes from the reviewed projects would total approximately 61 acres for Packery Channel. Impacts from Packery Channel would be mitigated through 91.3 acres of beach nourishment (covering beach and shallow Gulf bottom). Dune relocation and revegetation of 5,670 cy (approximately 1.5 acres) of dunes has been proposed for the Packery Channel project. Port Mansfield dredging operations for the 1992 study (EH&A, 1992) indicated that several disposal sites would mitigate as beach and/or shoreline nourishment for eroding sections in adjacent areas, but this was not quantified. Impacts to shore areas/beaches/dunes from the Brownsville Ship Channel project were not reported.

4.14.6.2 Physical/Chemical Resources

Increases in both upland and submerged elevations from dredged material placement with the DMMP alternative can be expected to cause minor changes in local circulation patterns.

Topography/Bathymetry

All reviewed projects impact topography/bathymetry: Packery Channel (3.5 miles), JFK Causeway (0.9 mile), and Brownsville (18.4 miles), BNP (2.3 miles), and Port Mansfield (9.5 miles). The DMMP alternative would impact 117 miles of estuarine topography (the length of the GIWW in the Laguna Madre). Periodic placement of maintenance material on open-water placement areas would temporarily decrease water depth in some areas along this distance until currents and wave action erode the dredged material away. Surface elevation would increase due to replacement of open bay with new structures associated with some reviewed projects.

Noise

Noise impacts from dredging projects would result from operation and maintenance noise. This impact would be temporary, would move up and down the project area depending on the section being dredged, and would not be expected to differ from current maintenance dredging for many of the projects. Construction noise related to the raising of the JFK Causeway and amenities associated with the Packery Channel project and the Brownsville Ship Channel project would be/were temporary and would/did occur during a single event. Such impacts are not anticipated to be significant.

Air Quality

Objectionable odors (mercaptan, hydrogen sulfide) may result from the dredging of maintenance sediments containing high concentrations of organic matter in those reviewed projects requiring dredging. Temporary and intermittent exhaust from maintenance dredging activities would emit nitrogen oxides and carbon monoxide primarily. During operation, pollutants expected to be emitted include nitrogen oxides, carbon monoxide, particulates, sulfur dioxides, and hydrocarbons. No reviewed projects are anticipated to violate the NAAQS because these projects require State air permits.

Therefore, the cumulative effects are considered insignificant since the region is and shall remain in attainment.

Water Quality

All recent projects, that are required to have them, would comply with the requirements of the National/Texas Pollutant Discharge Elimination System (N/TPDES) during construction of the projects. Although water quality in the general project area appears to be fine, dredging and placement operations are expected to temporarily degrade water quality in the project vicinity through increased turbidity and release of bound nutrients. This is true of all projects involving dredging and dredged material placement including all previous projects. However, no projects reviewed cited concerns with sediment contamination or nutrients.

Dredging and placement at proposed open-water and upland placement areas may increase suspended solids, release contaminants and bound nutrients, and deplete oxygen. This impact would be temporary and, perhaps except for turbidity, insignificant. If temporary degradation occurs, the study area should rapidly return to ambient conditions upon completion of dredging.

A slight impact to water quality may occur as a result of vehicular use of the elevated JFK Causeway. Stormwater runoff, which may contain oil and grease may also have minimal impacts to water quality there.

Salinity

The existing salinity condition is anticipated to be maintained as a result of dredging and maintenance of the majority of projects reviewed. Possible changes in hydrodynamics from the proposed JFK Causeway and Packery Channel may cause localized changes but would not be expected to change the salinity structure of the ULM as a whole (Hicks et al., 1999). The DMMP alternative would not alter the salinity regime beyond the current condition.

Freshwater Inflows

No alteration to freshwater flow is anticipated from the DMMP alternative or from any projects reviewed in this analysis.

Turbidity

Reviewed projects requiring dredging and open-water placement of dredged material would produce increased turbidity during dredging and placement, discussed in detail in sections 4.2.3 and 4.4.1. Continued use of open-water placement areas may provide a source of continuing turbidity due to erosion by currents and wave action. Turbidity would also often occur in the immediate vicinity of the cutterhead dredge, near the point of open-water placement, and from runoff from construction sites during highway projects. Turbidity from these sources is expected to return to concentrations below ambient soon after cessation of dredging.

Circulation/Tides

Temporary, minor changes in circulation in the vicinity of open-water placement areas containing newly placed materials are expected upon construction dredging and with the maintenance dredging process. Circulation is expected to return to existing conditions when the majority of the material has eroded away. No changes in turnover and tides are expected as a result of dredging the reviewed projects. Hicks et al. (1999) predicts a small, localized effect in hydrodynamics as water would be allowed to move through a 2,550-foot water opening in the proposed JFK Causeway, rather than the present exchange through Humble Channel and the GIWW only. The most significant changes in circulation would occur with the opening of Packery Channel. In the completed projects, opening the Brownsville Ship Channel and Port Mansfield Channel caused significant changes to the circulation in the LLM, but no significant circulation or tidal alteration from the latest deepening of either one was predicted.

Sediment Quality

Were there any potentially contaminated sediments from any of the reviewed projects, they would be placed in upland confined placement areas. Monitoring and management of the effluent from these sites would control reintroduction of these contaminants to the environment. The completed projects reported temporary turbidity plumes from initial dredging operations, however, EPA had oversight of the projects and a NPDES permit was required for each. For all reviewed projects, results of both chemical and biological analyses on sediments indicated that there were no particular pollution problems associated with dredging and disposal of sediment, which would contribute its toxicity or bioaccumulation.

4.14.6.3 Cultural/Socioeconomic Resources

No cultural impacts are anticipated as a result of the DMMP alternative. There is a low probability that unknown submerged archeological sites, excluding shipwrecks, may be impacted. Socioeconomic impacts relate mainly to local increases in population, increases in the demand for housing, and impacts to land use. One business would be relocated as a result of the construction of the JFK Causeway project but there would be no change relative to the No-Action alternative.

Secondary effects would occur as a result of all reviewed projects, except this one. Economic development in this area is anticipated to result in increased commercial and residential development on North Padre Island. Transportation access would be improved with new channel development projects and maintenance of existing channels. Transportation safety would be improved in all channel projects, except the DMMP alternative which would cause no change, and hurricane evacuation for Padre Island would be improved due to the JFK Causeway project.

Oil and Gas Production on Submerged Lands

Current oil and gas pipelines are placed to accommodate existing channel dimensions. Although some of the reviewed project documents did not address oil and gas production, no change in oil and gas production is anticipated as a result of the projects evaluated for cumulative impact assessment except for permitted activities. The number of permits issued between 1938 and 2002 totaled 320. Very few had quantifiable habitat impacts reported for the work performed; however, for oil and gas activity in the Laguna Madre, those that were quantified are included in Table 4-10. Of the permits issued, 24 listed impacts to open-water, 20 to SAV, 5 to shallow water areas, 1 to estuarine, 3 to wetlands, and 20 to flats.

Ship Accidents/Spills

Waterborne traffic under the DMMP alternative is expected to remain as currently projected for the existing condition. All reviewed projects may result in increases in waterborne traffic, which may subsequently increase the potential for spills. The potential for small accidental releases related to dredging activity would continue to exist; however, spill prevention plans can minimize impacts. No additional impacts are anticipated.

Historic Resources

Historic and archeological resources are not expected to be impacted by the DMMP alternative (see Section 4.11). None of the reviewed projects conflicts with sites currently listed on the NRHP or are designated as SALs.

Recreation

The Laguna Madre is widely used by recreational fishermen and boaters. Turbidity associated with dredging and placement is anticipated to temporarily damage local fisheries in small portions of the general project area but would decrease with the DMMP alternative. However, such impacts are similar to current conditions and because these effects are temporary and local, fisherman can move to other undisturbed locales during dredging and placement activities. Channel improvement projects like three of those reviewed provide greater access to and throughout the bay for recreational fishermen and boaters. Increased tourism would likely result from the opening of Packery Channel and the development of ancillary park facilities.

The Packery Channel project would impact approximately 25 acres of currently vacant land, 20 acres of which would be converted to public parkland (including parking and other structures). The cumulative effect on visitor usage of parks and recreational areas was not evaluated, as these impacts were not addressed in any of the project documents reviewed. However, potential secondary development related to improved access via the JFK Causeway is anticipated to increase tourist and recreational usage of North Padre and Mustang islands. The Packery Channel Project would also increase tourist and recreational usage in the North Padre Island area.

Commercial and Recreational Fisheries

Many commercially and recreationally important species of shrimp and finfish are common in the general project area, specifically red drum, spotted sea trout, black drum, mullet, southern flounder, brown shrimp, and pink shrimp. These species may be adversely affected by degradation of open-bay bottom foraging habitat due to open-water placement, but recovery is rapid (Ray and Clarke, 1999). Refer to Section 4.5.1 in this FEIS for impacts to commercial and recreational fisheries from the

DMMP alternative. The opening of Packery Channel is expected to increase opportunities for recreational fisherman.

Public Health

No impacts to public health are expected from the reviewed projects.

Safety

The primary purpose of elevating the JFK Causeway to a minimum of 9 feet MSL is to enhance public safety, particularly during natural emergencies such as hurricanes. Safety impacts to other reviewed projects were not indicated.

Parks and Beaches

No impacts to parks and beaches are expected from the reviewed projects except the Packery Channel project. Beach would be removed for channel construction, and beach nourishment in two areas would temporarily prevent use by the public but would improve long-term use.

4.14.7 Conclusions

Cumulative impacts due to past, existing, and reasonably foreseeable future projects, along with the DMMP alternative, were found to produce a net positive cumulative impact in the project area. Although some parameters would experience negative impacts, most of these impacts would be temporary and minor. Benefits realized through creation and protection of seagrass and tidal flats habitat by the DMMP alternative and some other projects, not including the project mitigation, resulted in a net improvement to the Laguna Madre during impact assessment, relative to the No-Action alternative.

4.15 MONITORING THE ENVIRONMENTAL IMPACTS OF THE DMMP

The management plans for handling placement of dredged material at each PA in the DMMP represent a reduction of impacts to the biological resources in the Laguna Madre relative to present practice. To determine if the goals for each PA are being achieved, the ICT expressed a need to monitor placement operations at the sites. Most of the concerns centered on the localized impacts at each PA and include the success of the beneficial use of dredged material on some islands to enhance bird use, reducing direct (burial) and indirect (turbidity plumes causing shading) impacts to seagrass, and the release of nutrients (ammonia) into the water column.

The ICT will work with the USACE to develop a monitoring plan that includes parameters to be monitored, locations and methodology to use, implementation responsibilities, and other details, as needed. After approval by the USACE, the monitoring plan will be attached to the DMMP as an appendix. The ICT will review the results of each monitoring effort and make recommendations to modify the monitoring plan or the management plans in the DMMP based on these results, if needed. This process will continue throughout the life of the project or until the USACE, with an ICT recommendation, determines that there is no need to continue monitoring the placement operations and collect data.

4.16 UNRESOLVED ISSUES

There is one major unresolved issue concerning management of dredged material placed in 10 PAs located inside the Congressionally authorized boundaries of PINS. Representatives of PINS, as nonvoting members of the ICT, raised the issue of nonimpairment of Park resources in a January 2001 meeting of the ICT. This meeting was held to discuss the procedures for completing the second iteration of the placement alternatives analysis. A summary of the PINS and USACE positions on this issue is provided below.

Placement Areas 182, 183, 185, 187, 188, 190, 191, 192, 194, and the northern portion of 195 are the existing PAs in question, along with one new PA (182S) proposed for creation in the DMMP (preferred alternative) by the PINS. PINS takes the position that all activities inside the Congressionally authorized park boundaries must comply with the NPS Organic Act, the park authorizing legislation, NPS regulations and management policies (2001), and other written NPS policy guidance and management documents.

The Organic Act of 1916 directs the NPS to conserve the scenery and wildlife and leave them unimpaired for the enjoyment of future generations. The Redwood Amendment (1978) emphasizes that the NPS shall protect and manage the resources of the park and ensure the values and purposes of the resources for which the park was established are not degraded. The PINS authorizing legislation established the park to save and preserve a portion of the diminishing seashore of the U.S. However, the superintendent of a park has the power under NPS regulations to issue special use permits to authorize otherwise restricted activities and to include terms and conditions the superintendent deems necessary to protect park resources or public safety.

NPS Management Policies allow the NPS to use dredged material for resource management purposes, as long as it is consistent with park planning documents and does not impair park resources and values. Some of these uses could be to renourish eroding shorelines, if caused by human activities, or aid in the management of habitat for colonial waterbird rookeries on islands created by placement of dredged material. Only limited manipulation would be authorized to mitigate man-caused changes. Furthermore, according to PINS, these impacts will be permitted only when necessary and appropriate to fulfill the purposes of the park, as long as the impact does not constitute impairment of the park's resources and values. All relevant NEPA documents, scientific studies, and public comments would be considered by the superintendent to determine if an activity represents an impairment of the park's resources before issuing a special use permit.

The USACE takes the position that under existing legislative authority and laws, USACE does not need a special use permit from PINS to place dredged material in these PAs. The GIWW was constructed and its PAs started in 1949, long before the PINS was established. In addition, the USACE has been using its authority to maintain the GIWW and place dredged material in open-bay PAs under its

Navigation Servitude which stems from the Constitution's Commerce Clause. The USACE's position is that if Congress wanted to place a limit on this authority, it would have to do so with specific language which was not provided in the PINS authorizing legislation.

Furthermore, the Arroyo Colorado Navigation District of Cameron and Willacy Counties granted a perpetual easement in 1947 to USACE to create the GIWW and for placement of dredged material in a 5,000-foot-wide strip on the east side of the GIWW. The State of Texas, when it ceded lands to NPS to create PINS, specifically stated in 1975 legislation that the navigation district may consent to the acquisition of surface land for inclusion in PINS. The navigation district never gave their consent for acquisition of these lands by PINS nor did USACE relinquish its right to the use of the 1947 perpetual easement to PINS. Therefore, the USACE's position is that PINS authority over these lands within the perpetual easement of the navigation district were taken subject to the perpetual easement and cannot require USACE to apply for a special use permit to place dredged material in the PAs.

Regardless of the interpretation of these laws, the USACE has been working with PINS through the ICT process to coordinate a DMMP that will reduce impacts to seagrass and other habitat located, not only within PINS, but in the entire Laguna Madre. The USACE and ICT have incorporated the PINS management plan in the DMMP to manage dredged material on the islands inside the PAs in PINS, to the maximum extent practicable. Examples of the management practices adopted in the DMMP include placing dredged material on the islands to enhance bird use and public recreation and directing sediment flow away from channels and seagrass beds.

At the request of PINS, the ICT has identified alternate PAs outside the Congressionally authorized park boundary for deposition of dredged material that is in excess of the park's plans for use. However, diversion of this excess material could overload the PAs on the west side of the GIWW and impact seagrass beds that have not been impacted in the past. Because this represents new impacts to the lagoon's ecosystem, the ICT requested an opportunity to review the dredging plans and quantities prior to dredging and make recommendations on placement locations that would provide the least impacts to the lagoon's ecosystem. This difference in view, PINS' narrow consideration of only the resources inside the park and the USACE and ICT's broader consideration of the entire lagoon's ecosystem, as well as PINS belief that the USACE must request a special use permit prior to using any PAs inside PINS, creates an unresolved issue between the USACE and PINS that needs to be resolved.

4.17 ANY ADVERSE ENVIRONMENTAL IMPACTS WHICH CANNOT BE AVOIDED SHOULD THE RECOMMENDED PLAN BE IMPLEMENTED

The DMMP alternative would result in adverse impacts to the benthos and fish of the Laguna Madre from dredging and placement of dredged material at open-bay sites; however, these impacts would be less than those under the No-Action alternative. Although 3,477 acres of SAV would likely be impacted during placement activities, due to the efforts that were made during the development of the DMMP, this is 1,307 acres less than would be impacted by the No-Action alternative.

4.18 ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES INVOLVED IN IMPLEMENTATION OF THE RECOMMENDED PLAN

The labor, capital, and material resources expended in the planning and construction of this project are irreversible and irretrievable commitments of human, economic, and natural resources.

4.19 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Most SAV and bay bottom covered by dredged material placed in open-bay sites will recover over time, if enough time elapses between placement events. This would result in short-term losses of productivity during the interim period. By completely confining some of the dredged material in upland placement sites in Reach 3, adjacent land will return to tidal flat habitat, thus resulting in increased productivity as algal mats become reestablished.

4.20 ENERGY AND NATURAL OR DEPLETABLE RESOURCE REQUIREMENTS AND CONSERVATION POTENTIAL OF VARIOUS ALTERNATIVES AND MITIGATION MEASURES

NEPA regulations in 40 CFR 1502.16 (e) and (f) requires a discussion of project energy requirements and natural or depletable resource requirements, along with conservation potential of alternatives and mitigation measures in an EIS.

Under the No-Action alternative, the energy requirements for maintaining the channel will continue as before. The recommended alternative for maintaining the channel is expected to require approximately the same energy (fuel) as the No-Action alternative after additional levees for confining or directing the flow of material are constructed at selected PAs.

5.0 COMPLIANCE WITH TEXAS COASTAL MANAGEMENT PROGRAM (TCMP)

Compliance with the Texas Coastal Management Program is documented in Appendix F. The project was reviewed and found consistent by the Coastal Coordination Council.

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6.0 CONSISTENCY WITH OTHER STATE AND FEDERAL PLANS

This FEIS has been prepared to satisfy the requirements of all applicable environmental laws and regulations and has been prepared using the CEQ's NEPA regulations (40 CFR Part 1500) and the USACE's regulation ER 200-2-2 (Environmental Quality: Policy and Procedures for Implementing NEPA, 33 CFR 230). The following section presents a summary of environmental laws, regulations, and coordination requirements applicable to this FEIS.

National Environmental Policy Act. This FEIS has been prepared in accordance with CEQ regulations in compliance with NEPA provisions. All impacts on terrestrial and aquatic resources have been identified.

Fish and Wildlife Coordination Act of 1958, as amended. This Act requires the FWS to prepare an official Fish and Wildlife Coordination Act Report (CAR). The preferred alternative has been extensively coordinated with the FWS and other State and Federal resource agency representatives on the ICT. The CAR will be included in the Final EIS as part of Appendix E, Public Involvement/Coordination, and will constitute compliance with the act.

National Historic Preservation Act of 1966, as amended. Compliance with the NHPA of 1966, as amended, requires identification of all NRHP-listed or NRHP-eligible properties in the Project area and development of mitigation measures for those adversely affected in coordination with the SHPO and the Advisory Council on Historic Preservation. As indicated in Section 4.11, this project will have no impacts on NRHP-listed or SAL-designated properties. This FEIS will be coordinated with the Texas SHPO.

Endangered Species Act of 1973, as amended. Interagency consultation procedures have been undertaken. A Biological Assessment describing the project area, Federally listed endangered and threatened species likely to occur in the area (as provided by the FWS and NMFS), and potential impacts on these listed species (see Appendix D) has been presented to the NMFS and FWS for review. The results of the assessment and agency comments will be published as an attachment to the Final EIS.

Clean Water Act of 1977, as amended. Sections 401 and 404 of the act apply to the preferred alternative and compliance will be achieved. A discussion based on the Section 404(b)(1) guidelines is included in this FEIS. The Section 404(b)(1) evaluation is presented in Appendix G.

In Texas, Section 401 of the Clean Water Act, the State Water Quality Certification Program, is regulated by the TCEQ. The TCEQ provides a Section 401 certification to the USACE indicating that activities in wetlands and other waters under State jurisdiction comply with the State's water quality requirements. A 401 State Water Quality Certification will be requested from the TCEQ and will be included in the Final EIS.

Coastal Barrier Improvement Act of 1990. This act is intended to protect fish and wildlife resources and habitat to prevent loss of human life and to preclude the expenditure of Federal funds that may induce development on coastal barrier islands and adjacent nearshore areas. Certain exceptions exist which allow for such expenditures. The proposed actions are exempt from the prohibitions identified in the act.

Executive Order 11988, Floodplain Management, May 24, 1977. This Executive Order directs Federal agencies to evaluate the potential effects of proposed actions on floodplains. Such actions should not be undertaken that directly or indirectly induce growth in the floodplain unless there is no practical alternative. The preferred alternative will not significantly affect the Laguna Madre floodplain.

Executive Order 11990, Protection of Wetlands, May 24, 1977. This Executive Order directs Federal agencies to avoid undertaking or assisting in new construction located in wetlands unless there is no practical alternative. The recommended plan is in full compliance with this Executive Order.

Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds, January 10, 2001. This Executive Order directs Federal agencies to increase their efforts under the Migratory Bird Treaty Act, Bald and Golden Eagle Protection Acts, the Fish and Wildlife Coordination Act, the Endangered Species Act of 1973, the National Environmental Policy Act of 1969, and other pertinent statutes as they pertain to migratory birds to avoid measurably negative take of migratory bird populations. The preferred alternative is in compliance with this executive order because the DMMP should not result in significant (if any) losses to migratory birds, particularly those considered of special concern.

Fishery Conservation and Management Act of 1996. Congress enacted amendments to the Magnuson-Stevens Fishery Conservation and Management Act (PL 94-265) as amended in 1996 that established procedures for identifying EFH and required interagency coordination to further the conservation of Federally managed fisheries. Rules published by NMFS (50 CFR Sections 600.805 – 600.930) specify that any Federal agency that authorizes, funds or undertakes, or proposes to authorize, fund, or undertake an activity that could adversely affect EFH is subject to the consultation provisions of the above-mentioned act and identifies consultation requirements.

EFH consists of those habitats necessary for spawning, breeding, feeding, or growth to maturity of species managed by Regional Fishery Management Councils in a series of Fishery Management Plans. Sections 3.5.3 and 4.5.3 of the FEIS were prepared to address EFH in the project area and meet the requirements of the act.

Marine Protection, Research, and Sanctuaries Act of 1972. This act requires a determination that dredged material placement in the ocean will not reasonably degrade or endanger human health, welfare, or amenities or the marine environment, ecological systems, or economic potentialities (shellfish beds, fisheries, or recreational areas). All construction material will be placed onto bay or upland areas.

Federal Water Project Recreation Act of 1995. This act requires consideration of opportunities for outdoor recreation and fish and wildlife enhancement in planning water resource projects.

Although specific recreational opportunities are not proposed as part of the project, improvements to bird islands would lead to increased birding opportunities as bird habitat is increased.

Texas Coastal Management Program. This act requires that all land use changes in the project area be conducted in accordance with approved state coastal zone management programs. Any project that is located in or which may affect land and water resources in the Texas coastal zone and that requires a Federal license or permit, or, is a direct activity of a Federal agency, or is Federally funded, must be reviewed for consistency with the TCMP. Section 5.0 and Appendix F address the compliance of the preferred alternative addressed in this FEIS with the CMP.

Farmland Protection Policy Act of 1981. The purpose of this act is to minimize the extent to which Federal programs contribute to unnecessary and irreversible conversion of farmland to nonagricultural uses. There will be no impacts to prime and unique farmlands from the preferred alternative.

Executive Order 12898, Environmental Justice. This Executive Order directs Federal agencies to determine whether the preferred alternative would have a disproportionate adverse impact on minority or low-income population groups within the project area. The preferred alternative would not significantly affect any low-income or minority population.

Clean Air Act of 1972. This act is intended to protect and enhance the quality of the nation's air resources, to initiate and accelerate research and development to prevent and control air pollution, to provide technical and financial assistance for air pollution prevention and control programs, and to encourage and assist regional air pollution prevention and control programs. The preferred alternative is in compliance with this act.

This Project is in Nueces, Kleberg, Kenedy, Willacy, and Cameron counties, which are in attainment for air quality. A Clean Air Act conformity analysis for the project is not required.

Marine Mammal Protection Act of 1972. This act, passed in 1972 and amended through 1997, is intended to conserve and protect marine mammals, establish a Marine Mammal Commission, establish the International Dolphin Conservation Program, and establish a Marine Mammal Health and Stranding Response Program. The proposed action will be in compliance with this act, such that certain species and population stocks of marine mammals will not be diminished beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part nor below their optimum sustainable population level.

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7.0 PUBLIC INVOLVEMENT

Review and consultation of this document was performed by the USACE and the ICT.

7.1 PUBLIC INVOLVEMENT PROGRAM

The USACE and the ICT involved the public through outreach programs such as public meetings, a world wide website (http://www.swg.usace.army.mil/items/Laguna/), and other outreach throughout the history of this project. A proactive approach was taken to inform and involve the public, resource agencies, industry, local government, and other interested parties about the project and to identify any concerns from the aforementioned groups (see Appendix E for more information).

In 1989, an interagency task force (Gulf Intracoastal Waterway Maintenance Dredging Working Group), composed of representatives of the FWS, NMFS, NPS, GLO, and TPWD, challenged sections of the existing 1975 EIS relative to its compliance with various environmental statutes. At the same time, several environmental groups and one land owner including the Lower Laguna Madre Foundation, the National Audubon Society, and the King Ranch also questioned the environmental effects of open-bay placement practices and the adequacy of the 1975 EIS in addressing these effects.

The first phase of additional Section 216 studies was initiated in 1993. The USACE Galveston District was responsible for the general management of that study with the State of Texas, represented by TxDOT, acting as the local sponsor. In addition, various other Federal and State agencies provided considerable input during this study. A Planning Aid Report was prepared by the FWS and three public scoping workshops were conducted on December 7–9, 1993 (USACE, 1994).

Continuing environmental concerns led to a 1994 lawsuit involving the National Audubon Society et al. vs. U.S. Army Corps of Engineers, Civil Action No. B-94-254. Because the USACE was conducting the above described review of the current maintenance and operation of the Laguna Madre section of the GIWW and its implementing regulations, the plaintiffs' claims were denied and the case dismissed on October 13, 1994.

The recommendations of the task force, coupled with environmental concerns from environmental organizations and the preliminary findings of the Reconnaissance Study, led to the decision to proceed with a Supplemental Environmental Impact Statement (SEIS). These processes also resulted in the formation of the ICT to help the USACE develop the scope of environmental studies and to help prepare a DMMP and FEIS.

After analysis of the environmental studies were completed, it was determined that a new EIS was needed rather than a supplemental to the 1975 EIS. Additional reasons for preparing a new EIS are provided in Section 1.1.

In addition to the three public scoping workshops in 1993, a public scoping meeting was held on September 26, 1996, two public involvement meetings were held prior to the release of the FEIS on October 28 and 29, 2002, and two public hearings were held on May 7 and 8, 2003.

7.2 PUBLIC VIEWS AND RESPONSES

Public views and concerns expressed during the study have been considered during the preparation of this FEIS. The view and concerns were used to develop planning objectives, identify significant resources, evaluate impacts of various alternatives, and identify a plan that is socially and environmentally acceptable.

7.3 STATEMENT RECIPIENTS

The following list includes those who were sent a copy of these documents along with a request to review and provide comments on the documents:

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8.0 LIST OF PREPARERS

Name	Title	Experience	FEIS Role
U.S. Army Corps of Engineers			
Carolyn Murphy	Chief, Environmental Resources Section	3 years, NEPA compliance and coordination 24 years, historic resource coordination and archeological survey and research work at Omaha and Galveston Districts. 2 years, research and survey work at the University of Texas.	NEPA compliance review and coordination.
Terrell Roberts, Ph.D.	Wildlife Biologist	18 years, environmental, threatened and endangered species impact analysis, Galveston District. 5 years fishery research, National Marine Fisheries Service. 4 years, Asst. Professor of Oceanography, Florida Institute of Technology. 5 years, oceanography research, Texas A&M University.	Overall preparation of the document, environmental impact analysis, Biological assessment and impact analysis for threatened and endangered species, and coordination of project with natural resource agencies.
Richard Medina	Chief, Planning and Environmental Branch	30 years, environmental effects of dredging and water and sediment quality analysis, Galveston District.	Project formulation and coordination. Reviewed and edited EIS.
Kristy Morten	Environmental Specialist	12 years, hazardous, toxic, and radioactive waste and water quality environmental assessments and impact analysis, Galveston District. 12 years, waste and water quality research and analysis, and regulatory implementation, Angelina & Neches River Authority.	Reviewed hazardous, toxic, and radioactive waste impact analysis.
Gary DeMarcay	Archeologist	16 years, cultural resource specialist for Fort Worth District, BIA, Navajo Nation, BLM, and Galveston District. 13 years in cultural resource management as a private contractor.	Reviewed cultural resources section.

Name	Title	Experience	FEIS Role
Christy Sorrels	Regional Economist	8 years, economist at Forth Worth District. 3 years, Economist at Galveston District.	Prepared the Alternative Transportation Modes analysis updates and financial evaluation of project construction costs.
Joe Hrametz	Chief, Navigation Branch	22 years, dredging and construction at the Galveston District.	Reviewed the EIS and worked on the DMMP.
Gloria Appell	Regional Economist	22 Years, navigation economics and financial analysis.	Prepared section of and reviewed alternative modes analysis and financial evaluation of project construction cost.
PBS&J			
Martin Arhelger	Vice President, Project Director	29 years, Environmental Assessment and Impact Analysis	Project coordination; water and sediment quality.
Lisa Vitale	Marine/Aquatic Biologist	10 years, Marine/Aquatic Biology	Assistant Project Manager, Essential Fish Habitat
Patsy Turner	Ecologist	17 years, Environmental Assessment and Impact Analysis	Assistant Project Manager, Document Review, Cumulative Impacts
Thomas Ademski	Environmental Planner	3 years, Environmental Planning and Noise Analysis	Noise
Clell Bond	Vice President, Cultural Resources Director	35 years, Archeology, Cultural Resources Management	Historical/Cultural Resources
Kathy Calnan	Ecologist, Botanist	13 years, Vegetation Analysis and Impacts	
Bob Gearhart	Archeologist; Magnetometer and Side-Scan Sonar Specialist	18 years, Marine Archeology	Historical/Cultural Resources – Marine
Derek Green	Biologist, Wildlife Specialist	20 years, Environmental Assessment and Impact Analysis	Wildlife and Habitat; Endangered and Threatened Wildlife Species

Name	Title	Experience	FEIS Role
Steve McVey	Geologist, HAZMAT Specialist	8 years, Environmental Geology	Hazardous Materials
Chris Moore	Environmental Planner	6 years, Urban and Environmental Planning	Land Use; Environmental Justice; Socioeconomics
Robert Rogers	Archeologist, Geoarcheologist	20 years, Geomorphology	Historical/Cultural Resources – Terrestrial
Ruben Velasquez, P.E.	Senior Engineer, Air Quality Specialist	19 years, Air Quality Analysis	Air Quality
Meg Cruse	Director, Archaeology Laboratory	18 years, Archaeology/Cultural Resources	Historical/Cultural Resources – Terrestrial
Bonnie Lister	Ecologist II	4 years, Ecological Studies, Document Preparation and Review	Document preparation and review
Tom Church	Sr. GIS Analyst I	5 years, GIS	Placement area, aquatic vegetation, and land use figure preparation
David Kimmerling	Graphics Specialist	18 years, Graphics	Figure preparation
Matt Qualls	GIS Analyst II	4 years, Cartography, GIS	Placement area, aquatic vegetation, and land use figure preparation
Bob Bryant	Word Processing Specialist	13 years, Word Processing	Text and table creation and importation; document formatting

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9.0 REFERENCES, ABBREVIATIONS AND INDEX

9.1 REFERENCES CITED

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9.2 ACRONYMS AND ABBREVIATIONS

°C	degrees Centigrade
°F	degrees Fahrenheit
A.D.	*Anno Domini* or "in the year of the Lord"
ac	acres
ADV	acoustic Doppler velocimeter
ANOVA	analysis of variance to assess effects of locale
ATV	all-terrain vehicles
AWOIS	Automated Wreck and Obstruction Information System
B.C.	before Christ
BIH	Brazos Island Harbor
CAR	Center for Archeological Research
CAR	U.S. Fish and Wildlife Coordination Act Report
CASI	Compact Airborne Spectrographic Imager
CBBP	Coastal Bend Bays Plan
CBI	Conrad Blucher Institute for Surveying and Science (CBI) at Texas A&M University–Corpus Christi
CC	Corpus Christi
CCBCS	FWS Corpus Christi Bay Complex Study
CCBNEP	Corpus Christi Bay National Estuary Program
CCS	Center for Coastal Studies
CFR	U.S. Code of Federal Regulations
CO	carbon monoxide
CPD	cycle per day (power spectra of wind)
cy	cubic yards
Db	decibel
dBA	A-weighted decibel
DCP	Dissolved Concentration Potential
DDT	1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane
DMMP	Dredged Material Management Plan
DOQQ	Digital Orthographic Quarter-Quads
E/SA	endangered due to similarity of appearance
EFH	Essential Fish Habitat
EH&A	Espey, Huston & Associates, Inc.
EIS	Environmental Impact Statement

EJ	Environmental Justice
EMAP	EPA Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
ERL	Effects Range Low
ERM	Effects Range Medium
ESA	Endangered Species Act
FNG	flat-nesting guild
FWS	U.S. Fish and Wildlife Service
GIWAC	Gulf Intracoastal Waterway Advisory Committee
GIWW	Gulf (of Mexico) Intracoastal Waterway
GLO	Texas General Land Office
GMFMC	Gulf of Mexico Fishery Management Council
GPS	global positioning system
HTRW	hazardous, toxic, and radioactive waste
HUD	U.S. Department of Housing and Urban Development
Hz	Hertz
ICT	Interagency Coordination Team
LANWR	Laguna Atascosa National Wildlife Refuge
L_{dn}	day-night sound level
L_{eq}	equivalent sound level
LLM	Lower Laguna Madre
LOP	life-of-project
LPC	Limiting Permissible Concentration
MCY	million cubic yards
mg/L	milligrams per liter
MLT	mean low tide
mph	miles per hour
MZ	Mixing Zone
NAAQS	National Ambient Air Quality Standards
NED	National Economic Development
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NO_2, NO, NO_3, NO_x	Nitrogen dioxide (NO_2), nitric oxide (NO), and nitrate radical (NO_3) are collectively called nitrogen oxides (NO_x)
NOAA	National Oceanographic and Atmospheric Administration

NPS	National Park Service
NRHP	National Register of Historic Places
NWR	National Wildlife Refuge
O_3	ozone
OBC	Open-Bay Confined
OBS	optical backscatter
OBSC	Open-Bay Semiconfined
OBUn	Open-Bay Unconfined
OcnP	Ocean Placement by Pipeline
ODMDS	Ocean Dredged Material Disposal Sites
PA	Placement Area
PAR	photosynthetically active radiation
Pb	lead
PINS	Padre Island National Seashore
PM	Port Mansfield
$PM_{[n]}$	particulate matter with an aerodynamic diameter of [*n*]
pmd	pipeline-mile-days
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
ROW	right-of-way
SAL	State Archeological Landmark
SAV	submerged aquatic vegetation
SCC	Southern Coastal Corridor (Archeological Region of the Central and Southern Planning Region of Texas)
SCS	Soil Conservation Service
SEIS	Supplemental Environmental Impact Statement
SF3	Summary File 3 (data-set for the 2000 Census)
SO_2	sulfur oxides
SP	solid phase (bioassay and bioaccumulation data)
SPMA	Southwest Parks and Monuments Association
SPOT	Systeme Probatoire pour l'Observation de la Terre (satellite imagery)
SWQM	TNRCC's Surface Water Quality Monitoring
TAMU-CC	Texas A&M University at Corpus Christi, Texas

TCEQ	Texas Commission on Environmental Quality (formerly known as the Texas Natural Resource Conservation Commission, or TNRCC)
TCMP	Texas Coastal Management Program
TCOON	Texas Coastal Ocean Observation Network
TDS	total dissolved solids
THC	Texas Historical Commission
TNHP	Texas Natural Heritage Program
TNRCC	Texas Natural Resource Conservation Commission
TOC	total organic carbon
TOS	Texas Ornithological Society
TPH	total petroleum hydrocarbons
TPWD	Texas Parks and Wildlife Department
TSS	total suspended solids
TWC	Texas Workforce Commission
TWDB	Texas Water Development Board
TWQS	Texas Water Quality Standards
TXBCD	Texas Biological and Conservation System
TxDOT	Texas Department of Transportation
UCPA	Unconfined Placement Area
ULM	Upper Laguna Madre
UpC	Upland Confined
UpTL	Upland Thin Layer
USACE	U.S. Army Corps of Engineers
USBOC	U.S. Bureau of the Census
USCG	U.S. Coast Guard
USGS	U.S. Geological Survey
UTMSI	The Marine Science Institute of The University of Texas
VOC	volatile organic compound
ZID	Zone of Initial Dilution

9.3 GLOSSARY

The following definitions are for the convenience of those reading this Environmental Impact Statement and do not replace definitions in state, Federal, or local laws, regulations and ordinances.

anthropogenic – Relating to, or resulting from, the influence of humans on nature (e.g., anthropogenic pollution).

asphaltum – A naturally occurring tar that washes up on beaches from petroleum seepages on the Gulf floor.

bathymetry – The measurement of depths of water in oceans, seas and lakes and the information derived from such measurements.

benthos – Aquatic bottom dwelling organisms which include worms, leeches, snails, flatworms, burrowing mayflies, clams.

bioaccumulation – The accumulation of contaminants in the tissues of organisms through any route, including respiration, ingestion, or direct contact with contaminated water, sediment, or dredged material.

biomass – The mass of living material in a given area or volume of habitat.

brackish water – A mixture of fresh and salt water.

coastal zone – Coastal waters and adjacent lands that exert a measurable influence on the uses of the sea and its ecology.

confined disposal – Placement of dredged material within diked nearshore or upland confined disposal facilities (CDFs) that enclose the disposal area above any adjacent water surface, isolating the dredged material from adjacent waters during placement. Confined disposal does not refer to subaqueous capping or contained aquatic disposal.

contaminant – A chemical or biological substance in a form that can be incorporated into, onto, or be ingested by and that harms aquatic organisms, consumers of aquatic organisms, or users of the aquatic environment.

coquina (beach rock) – Natural hard-substrate areas formed of shell and coral fragments dating back to the late Pleistocene-early Holocene era.

crustacean – A group of aquatic animals characterized by jointed legs and a hard shell which is shed periodically, e.g., shrimp, crabs, crayfish, isopods, and amphipods.

deadweight tonnage (DWT) – A ship's load, including the total weight of the cargo, fuel, and stores.

demersal – At or near the bottom.

detritivores – Organisms that feed on detritus (fragments of plant or animal remains).

dredged material – Material excavated from waters of the United States or ocean waters. The term dredged material refers to material which has been dredged from a water body, while the term sediment refers to material in a water body prior to the dredging process.

effluent – A discharge of pollutants into the environment, partially or completely treated or in its natural state. Generally used in regard to discharges into waters.

Environmental Impact Statement (EIS) – A document prepared on the environmental impact of actions significantly affecting the quality of the human environment and used as a tool for decision-making.

Essential Fish Habitat (EFH) – Those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.

genus – A category of biological classification ranking between the family and the species, comprising structurally or phylogenetically (evolutionary relationship) related species and being designated by a Latin or latinized capitalized singular noun.

groundwater – The supply of freshwater under the earth's surface in an aquifer or soil that forms the natural reservoir for man's use.

habitat – The specific area or environment in which a particular type of plant or animal lives. An organism's habitat provides all of the basic requirements for the maintenance of life. Typical coastal habitats include beaches, marshes, rocky shores, bottom sediments, mudflats, and the water itself.

hydrogen sulfide (H_2S) – A malodorous gas made up of hydrogen and sulfur with the characteristic of odor of rotten eggs. It is emitted in the natural decomposition of organic matter and is also the natural accompaniment of advanced stages of eutrophication. H_2S is also a byproduct of refinery activity and the combustion of oil during power plant operations. In heavy concentrations, it can cause illness.

infauna – Animals which live within the sediment of the sea bottom.

intertidal zone – The marine zone between the highest high tide point on a shoreline and the lowest tide point. The intertidal zone is sometimes subdivided into four separate habitats by height above tidal datum, typically numbered 1 to 4, land to sea.

isopod – A small, flattened crustacean belonging to the order Isopoda.

lagoon – A shallow body of seawater generally isolated from the ocean by a barrier island. Also the body of water enclosed within an atoll, or the water within a reverse estuary.

larva (pl. larvae) – An embryo that differs markedly in appearance from its parents and becomes self-sustaining before assuming the physical characteristics of its parents.

lead – A heavy metal that may be hazardous to human health if breathed or ingested.

lithic debitage – Remnant unmodified lithic material resulting from tool manufacture.

low tide – The lowest limit reached by a falling tide.

macroinvertebrate – An invertebrate (lacking a backbone) large enough to be seen without magnification.

mean low low water (MLLW) – The average height of all the lower low waters recorded over a 19-year period, or a computed equivalent period; usually associated with a tide exhibiting mixed characteristics.

mean low tide (MLT) – The average height of all the low tides at a given place, usually over a period of 19 years.

mean sea level (MSL) – The mean surface water level determined by averaging heights at all stages of the tide over a 19-year period. MSL us usually determined from hourly height readings measured from a fixed predetermined reference level (chart datum).

mercury – A heavy metal, highly toxic of breathed or ingested. Mercury is residual in the environment, showing biological accumulation in all aquatic organisms, especially fish and shellfish. Chronic exposure to airborne mercury can have serious effects on the central nervous system.

nekton – Free-swimming organisms inhabiting the open water.

open-water disposal – Placement of dredged material in rivers, lakes, estuaries, or oceans via pipeline or surface release from hopper dredges or barges.

organism – Any living human, plant, or animal.

particulate matter – Very fine solid or liquid particles in the air or in an emission, including dust, fog, fumes, mist, smoke, and spray, etc.

permitted – Used to mean 1) required to have a permit from an agency, or 2) having received such a permit through a process that includes a written application and a formal review by an agency.

physiography – A landscape whose parts exhibit similar geologic structures and climate, and whose pattern of topographic relief differs significantly from that of adjacent landscapes, indicating a unified geomorphic history.

phytoplankton – Plantlike, usually single-celled members (generally microscopic) of the plankton community.

planktivores – Organisms that feed on plankton.

plankton – Drifting or weakly swimming organisms suspended in water. Their horizontal position is to a large extent dependent on the mass flow of water rather than on their own swimming efforts.

planktonic – Floating in the water column.

polychaetes – Segmented worms, mostly marine, bearing paddle-like appendages on the body segments which, in turn, carry numerous bristles.

polychlorinated biphenyls (PCBs) – a group of organic compounds used in the manufacture of plastics. In the environment, PCBs exhibit many of the same characteristics as DDT and may, therefore, be confused with that pesticide. PCBs are highly toxic to aquatic life, they persist in the environment for long periods of time and are biologically accumulative.

producers – Photosynthetic green plant or chemosynthetic bacteria, constituting the first feeding level in a food chain.

Record of Decision – A comprehensive summary required by National Environmental Policy Act that discusses the factors leading to U.S. Army Corps of Engineers (USACE) decisions on regulatory and Civil Works matters and is signed by the USACE District Engineer after completion of appropriate environmental analysis and public involvement.

runoff – The portion of rainfall, melted snow, or irrigation water that flows across ground surface and eventually is returned to streams. Runoff can pick up pollutants from the air or the land and carry them to receiving waters.

sediment – The layer of soil, sand, and minerals at the bottom of surface water that absorbs contaminants.

serpulid reefs– Reefs composed of the calcareous tubes of serpulid polychaete worms.

shell middens – An archeologically significant refuse pile that consists primarily of discarded mollusc shells but may contain other materials, indicating the subsistence strategies of the prehistoric and historic indigenous inhabitants.

surface water – Water on the earth's surface exposed to the atmosphere as rivers, lakes, streams, and oceans.

swash – The rush of water onto the beach following the breaking of a wave.

terrigenous clastics – sandstones, conglomerates, breccias, and mudrocks.

Texas Commission on Environmental Quality (TCEQ) – On September 1, 2002, the Texas Natural Resource Conservation Commission changed their name to the Texas Commission on Environmental Quality.

Texas Natural Resource Conservation Commission (TNRCC) – On September 1, 1993, the Texas Air Control Board, Texas Water Commission, and parts of the Texas Department of Health merged and became the TNRCC.

Texas Pollutant Discharge Elimination System (TPDES) – The major program for regulating municipal and industrial wastewater discharges through the permitting of wastewater treatment facilities. In 1998, TNRCC took over the administration of this program in Texas, formerly the NPDES, administered by the U.S. EPA.

total petroleum hydrocarbons (TPH) – a large family of several hundred chemical compounds that originally come from crude oil.

toxic pollutant – Pollutants, or combinations of pollutants, including disease-causing agents, that after discharge and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will, on the basis of information available to the Administrator of the U.S. Environmental Protection Agency, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, or physical deformations in such organisms or their offspring.

turbidity – An optical measure of the amount of material suspended in the water. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. High levels of turbidity may be harmful to aquatic life.

Volatile organic compounds (VOC) – Secondary petrochemicals, including light alcohols, acetone, trichloroethylene, perchloroethylene, dichloroethylene, benzene, vinyl chloride, toluene, and methylene chloride, which are used as solvents, degreasers, paint thinners, and fuels. Because of their volatile nature, they readily evaporate into the air, increasing the potential exposure to humans. Due to their low water solubility, environmental persistence and widespread industrial use, they are commonly found in soil and groundwater.

wetlands – Areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support and that, under normal circumstances, do support a prevalence of vegetation typically adapted for life in saturated-soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (40 CFR Part 230), especially areas preserved for wildlife, zooplankton (planktonic animals that supply food for fish).

zooplankton – Animal members of the plankton community.

9.4 INDEX